Learning Through the Use of CAD and 3D-RP Modeling
(From Experience by Collaboration and Communication)

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Abstract
The National University Corporation of Tsukuba University of Technology (NTUT) introduced an inkjet type 3D modeling machine in 2007. Since then, we have been using the machine for the education of design drawing, and collecting data on experience and knowhow for effective use. This report describes how NTUT manages Self-Realizing Education where 3D CAD and 3D modeling are used effectively as a communication and a collaboration tool to motivate hearing-impaired students to receive high quality education of design drawing. And more, “Collaborative Work” that was not possible in the age of 2D CAD has become possible.
Visibility is indispensable and useful in education of design drawing. Referring to what is visible, we can communicate with each other and exchange concrete views to evaluate mutually and enhance understanding. NTUT has an education system which provides cooperative education in mechanical design drawing and CAD drawing in collaboration with Tokyo City University (TCU) which leads drawing education in Japan, giving high-quality education in design drawing. It is necessary to be excited to see and feel the high-grade approach and performance of students from other colleges and the real thing. CAD education has realized cooperative education in that we can operate classes by referring to concrete examples of 3D models.
And then, it is important to have collaborations with a company. Knowing the enterprise teaching methods and actual situation leads to the real mechanical design and drawing education.
Keywords: collaboration, 3D CAD and 3D-RP modeling, self-realizing education, creative design, realizing communication,

1 Introduction
The Tsukuba University of Technology is the only institute of higher education for the hearing and the visually impaired in Japan. Our aim is to make our hearing and visually impaired students socio-economically independent and able to participate in and contribute to social development as active professionals.

Educational support is provided to students with hearing impairments so that they can visually understand the basic concepts of mechanical engineering, for instance, the design, drawing, and processing methods. We aim to educate using teaching methods that the students with hearing impairments can effectively understand by fully engaging their senses in an appropriately prepared educational environment. One approach is modeling, and we are teaching students such that they can actively experience and understand the know-how of designing with communication and collaboration.

This report describes that NTUT manages Self-Realizing Education where 3D CAD and 3D-RP modeling are used effectively as a communication tool through collaboration to motivate hearing impaired students to receive high quality education of design drawing.

2 Approach in design drawing education of NTUT
NTUT Faculty of Industrial Technology is a technology faculty to educate hearing impaired students. Department of Industrial Information has two courses, Mechanical Engineering Course and Architectural Engineering Course. The author educates students in Mechanical Engineering Course about machining method, mechanical design drawing exercise,
CAD/CAM/CAE related subjects, relative experiments

and practices, etc. and also leads CAD basic exercise, etc. as a basis of special subject for first year students before entering courses. These subjects are not special but the same as those for ordinary colleges so that NTUT students will be able to be independent highly in society.

2.1 Approach in class for mechanical design and drawing

As a matter of course, the class for second year students will start with the first step of JIS mechanical drawing for special subject and mechanical design drawing.

In the first half of second year, students exercise manual drawing and in the latter half 2D CAD drawing. After practice of how to write characters and how to draw lines, manual drawings starting with "V block" are drawn. During in the summer holidays, hand-drawings are redrawn by 2D CAD as a special training.

Students realize CAD operation through the special training. As the drawings are those once prepared and students know where to be careful about, CAD drawing is easily accomplished, even though they are requested to revise over and over again, In the beginning of exercise, however, quite a few students are confused to see the drawing does not match the real shape. So, we let students see the 3D model with accurate dimensions produced by 3D modeling machine. Thus, we tell students rightly what we intend to transmit aiming their deep understanding.

2.2 Preparation and use of drawing model as text

We use drawing models as a presentation text to explain the shape of product, even though it cannot be produced easily as a real product.

We lead students not only to study drawing through the preparation of bolt and nut drawings, but also to study machining in connection with drawing in such a way that students exercise, marking-off, manual finishing like filing, and machining in accordance with the drawing, and also measure surface roughness and perform 3D measurement in mechanical engineering test. Students check and evaluate the measurement results referring to the figures like surface roughness, etc shown in the drawing.

2.3 3D model creation from 3D CAD drawing

In the second year, students learn 2D CAD drawing, and in the first half of the third year they change all drawings they have ever provided into 3D CAD drawing. We carry out 3D modeling with STL data which are converted from CAD drawing data. In mechanical engineering classes, the author takes special consideration to lead students to realize by themselves to provide practical drawings which enable the machining of real product, not an imaginary product existing in virtual environment like cartoon film.

Students provide drawings, based on which they produce 3D models. We can see the understanding level of each student from the drawings and models they have produced. It is possible to issue detailed instructions referring to such respective understanding levels of students. It is also observed that models help students deepen their understanding by self-realization. In 3D models, students reflect their understanding levels much deeper than those obtained during the preparation of manual 2D drawings and 2D CAD drawings. Such improvement in design drawing techniques can be seen more concretely by themselves, friends and teachers.

Visibility is indispensable in NTUT. Referring to what is visible, we can communicate each other and exchange concrete views to evaluate mutually and enhance understanding.

3 Expanding text development and cooperative education

Because of a set of 3D modeling machine we are using in NTUT, cooperative education is being expanded through the use of 3D modeling machine among Mechanical Engineering course, other courses, other departments, further other colleges and international exchange. 2D CAD drawing is provided individually, even though time consuming, but the production of 3D CAD drawing and 3D model enables cooperative work. While students prepare drawings and produce models jointly, they realize by themselves, learn mutually to get more aware of CAD for manufacturing. Students produce the model of hand winch by group work.

Even if it will be a simple example, it is important to learn from manufacturing to fit the concept and how to make it through experiences. Learning the sense of manufacturing is important for mechanical drawings for 3D CAD.

NTUT has an education system to provide cooperative education in mechanical design drawing and CAD drawing in collaboration with Tokyo City University(TCU) which leads drawing education in Japan, giving high-quality education in design drawing. It is necessary for NTUT students not to become a frog in the well, but to be excited to see and feel the high grade approach and performance of other colleges students. CAD education has realized cooperative education that we can operate classes referring to concrete examples of 3D models.

NTUT has overseas collaboration with Bauman Moscow State Technical University(BMSTU). As part of cooperative education between NTUT and one of centers in BMSTU where hearing impaired students learn, hold a competition in science, technology and educational program "Step into the Future" for students. Students from NTUT participated every year in the competition to give research presentation through video conferencing system connected to Moscow. NTUT students received good evaluation for the research presentation on 3D modeling and its precision every year.

4 Designer's responsibilities for high quality drawing

In the end, all quality requirements return to the drawing. Drawing, not just tracing, must reflects all requirements for manufacturing, so designers carry heavy responsibilities. We must try to develop right communication to realize thinking drawing form tracing drawing. There is a video that we always show

students in the class of drawing. The video says strongly that drawing is the language of engineers. Teacher Kiyoshi Ohnishi says in the video, “Drawing is a communication tool of engineers …” His words encourages NTUT students. It carries heavy responsibilities to provide a drawing to transmit the requirements rightly to readers. We try to develop right communication by finding out the exchange of words in drawings.

I believe that it is a good way to teach real drawings through making a chance to communicate each other using mechanical drawings which were written by themselves. Having some other party to convey information by the drawing, it will be a drawing in thinking about the partner, understanding how to draw correct drawing.

4.1 Issues in machining when 3D printer is used

Inkjet type 3D printer creates various shapes seamless. 3D CAD is not applicable to those shapes that can not be manufactured by ordinary machining methods and as a result 3D CAD creates such shapes that can not be machined actually. To avoid troubles afterwards, it is necessary to consider ordinary machining methods well in design.

4.2 Effective use of 3D printer features

Precision of 3D printer products are different corresponding to each machine, and deformation after machining is also expected. As the specifications of model are also influenced by the material of work, models are not always usable as an almighty product. We need to select a right material at a right place, when we produce a 3D model. For effective using of 3D printer, thinking about it’s feature is necessary.

4.3 For more development in NTUT

We would like to enhance the effective utilization of 3D CAD and 3D modeling in order to lead students to recognize by themselves that they must have responsibilities as a mechanical designer to provide drawings. It is important to talk to students in a mechanical drawing class that there are other parties to convey information by his or her drawings. We consider that 3D CAD and 3D modeling is one of the best tools to have NTUT students learn mechanical designer’s sense while gaining experiences, move forward clearing various kinds of subjects by themselves, and sharpen their senses to do their best.

As drawings are considered as a tool for communication or conversation, there must be a partner to read and use the drawings, so we would like to develop the cooperative education so that students can improve each other by the communication through drawings.

As it is said “drawing is the language of engineering” as a tool of communication for engineers, to learn drawing means to become an industrialist, so we would also like students to realize that communication is possible internationally through drawings. We expect to develop these kinds of opportunities through the international cooperative education. It is in practice just now.

On the other hand, students seem to think simply that the completion of drawing is the completion of engineering. We would like to plan such a way of education to lead students to verify the rightness of drawing after the production of 3D model. In preparation of 3D CAD drawings, special instructions are needed considering the way of fabrication. Special care must be taken not to create a model which needs an extraordinary way of fabrication. In 3D modeling, dimensional tolerance must also be taken into consideration. Students need to include all required information in the drawing regarding manufacturing procedures.

The cooperative work to assemble a 3D model in accordance with 3D CAD drawings is most effective for NTUT students to realize that drawings are one of tools for communication, and gives a good opportunity to students to think how exactly they present their own information. As a matter of course, actual experience in manufacturing is indispensable in drawing education. Recent experience in education through 3D modeling suggests us that practical knowledge by experience is important more and more in design drawing education. And one more important thing is to know about the method of CAD/CAM education at the company.

In advanced CAD / CAM and mechanical design and drafting, thinking about it as the content in line with the age of education that is ongoing at the university. And finally, it becomes necessary, if the work of the modern enterprise is involved in any design drafting. And how they are conducting education in the enterprise company for it. And nowadays the necessity is to explore concepts which are the base methods.

And, then we get to learn from the concept of companies that develop employees to perform mechanical design and drawing is as follows.

5 Learning from the enterprise company

Searching after how does an unknown thing the plan and design and make how it is the translation that must support the design power that makes present actually.

To put it differently, we make the caricature that expresses each source, mechanism of the design on the basis of specification with the early period stage of the design. Furthermore we grope the demand that thinks and would like you to design this sort of thing of the visitor tip continually and search the hint and make the request caricature. This process is the starting point of a design and will said that 60% of the designs ended with this stage.

5.1 Realizing communication by exchanging digital information

3D CAD should realize an effective environment for communication among those who require accurate and complete data regarding production and techniques, whenever and wherever data are needed, by a suitable means and at a low cost. In other words, 3D CAD should help to realize accurate and speedy communication.

The most important factor in realizing such communication is product data management (PDM), which enables integrated management and real-time responses on the basis of digital information.

5.2 Examination using punch drawings

The imaging of an idea, namely, the representation of an idea using pictures and characters, is the most

suitable method for maximizing the possibilities of designing at operating branches and for simply explaining information.

In designing, the designer focuses on a blank sheet of paper, lets the mind wander, and draws a component. Creating an idea for a design probably means incorporating new ideas into the shape while considering the shape of new products by imaging the shape of products that are already known, that is, the products the designer had previously seen and touched. We think that 3D CAD is unnecessary up to this stage of designing.

5.3 CAE as a tool for designers

Designers wish not only to simply request an analysis and wait for the result from a specialist but also perform analyses themselves and obtain the required result within a day so they may progress to the next step in the design. To realize this goal, we must perform several tasks, including ① the development of a CAD-CAE integrated system, ② the establishment of modeling and evaluation methods, and ③ the development of a support system for design.

5.4 Problems caused by decrease in the number of prototypes produced

The decrease in the number of production of prototypes has led to a reduction in the opportunities to learn from manufacturing substantial products.

In a design method, design skills for achieving mechanical requirements such as light weight and high stiffness, production technology that enables the timely provision of products in accordance with users' needs, and manufacturing technology that realizes the value of products at an appropriate cost, comprise the framework of manufacturing. However, full attention should be paid when these skills and technologies are applied.

5.5 Results of CAE depend on experience and sense

There is an obvious difference in the quality of design between designers, depending on their skill, even when the same tools are used. This can be regarded as a problem in training. In other words, designers are required, not only to learn how to use CAE, but also to have the ability to decide, in order to accurately examine the behavior of objects. Decisions are supported by experience and sense, which can be gained from experiments and theoretical considerations.

When we receive an order from a customer, the requested specifications are presented by the customer. We then aim to manufacture and realize products with functions that meet these specifications within a budget. This is the goal of design.

As design efficiency and cost performance are sought, the adoption of familiar designs that use existing techniques rather than techniques that require tests of new elements is frequently observed. As a result, in recent years, fewer trial and error methods have been carried out in the process of design, and priority has been given to design efficiency.

6 Conclusions

We cannot easily imagine the nature of design without any 2D drawings. What is most important in design is how accurately product information can be conveyed to manufacturers.

3D CAD is merely a tool in the design process, and produces no products in practice. It is expected that most of the design processes will be carried out automatically using computers through an innovative change in design business. However, a question arises whether it is acceptable to leave all the manufacturing-related work to computers.

After all, we believe that people are still the most reliable, with the flair, experience and skills that they have cultivated for a long time.

Innovation in design work is clearly necessary, but we should have good judgment in determining its direction.

I want to teach students the fun of Mechanical Design and Drawing, learning from their experiences. Therefore they,

- Learn from the enterprise, like from a university.
- Immerse themselves in a class.
- Acquire a good sense.
- Put emphasis on learning the sense, before considering advancements in technology and skill.
- Think deeply.
- Self-evaluate, improve and advance onward.
- Appreciate that Mechanical Design and Drawing contain the origin of human joy.

Mechanical Design and Drafting, CAD / CAM / CAE education, finally come at this stage.

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