

A case study on computer-aided drafting for vocational training competitions

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ABSTRACT: This study explores the distinguishing characteristics of student recipients of the Golden Hand Award, a vocational training competition in the area of computer-aided drafting (CAD) and seeks to generalise the instructional strategies of the teachers who trained the awarded participants. This study used qualitative research methods to interview five instructors and five students from the department of drafting at a vocational high school in Taiwan. The results reveal that successful technical skill learning must consider participants' thinking and exploration, repetitive practices, problem finding and solving, and teachers' innovative integration of instructional strategies. The personal traits of the students who won the Golden Hand Award include activeness, initiative, responsibility, stable emotions, high pressure resistance, and excellent spatial and drawing skills.

INTRODUCTION

Technical learning involves utilising a range of sense-making capacities and assumes physical action, as well as knowledge acquisition as essential components for understanding [1]. Since skill teaching involves the use of mechanical equipment or tools, its learning environment is more complicated, dynamic and diverse than the one for general disciplines [2]. Skill learning, apart from knowledge and facts, places emphasis on the students' acquisition of motor skills and other capabilities through exercises or practical application sessions.

Skill learning starts from the cognitive stage [3]. When people begin to learn skills, they mostly understand the operational way through the instruction and modelling provided by the teacher, in which the complexity of the skill can influence the cognitive period. Skill learning must be coordinated with perception and action. All these are in the cognitive stage, which are then changed into habits and skills through repeated practice or application. Thus, skill learning must be aided by repeated practice over a long period, so that the learner can be proficient in the said skills. Skill learning is also a process that combines the individual intelligence and actions, which is also a chain of multiple reactions and multiple actions, so it is, therefore, more complicated than learning an action [4].

It is mainly the learning of new reactions or actions, which needs effort and time to complete. The skill learning procedure and action development depend on physical development and training [5]. Chang thought that skill learning involves instructing students on how to present certain actions at the right time and in the right place [6]. The learning of general motor skills can be divided into two parts: actions and skills. Actions are learned through observation, and then the skills follow. Therefore, the actions must be learnt prior to the skill being learnt. Motor skills are developed so that the right actions are performed at the right time, and in the right place.

The aim of vocational education is to cultivate the skills needed by the occupation and to establish the correct vocational attitude [7]. However, vocational education is subject to constant social change, technical development and organisational demand [8]. In the current Taiwanese vocational education system, the teaching strategy for technical instruction is based on the students' talents and it affects the skill learning outcomes of the students due to the difference in the teachers' approach. Learning professional knowledge and skills are the focal points of vocational education. The original goal of education is to allow students to master their basic skills. The period in vocational high school is the basic stage for skill learning and competence cultivation, so skill learning during the vocational education period cannot be overlooked. For the teaching strategies, there are no related studies on whether teachers should adjust their teaching strategies to the demands of each course. This study allows the teachers in vocational schools to have a better understanding of the factors influencing the learning process of the awarded students of the computer-aided drafting programme in the Vocational Training Competition and, therefore, be able to select the appropriate teaching strategies to improve teaching efficiency.

METHODOLOGY

This study was able to generate some suggestions from the instructors and awarded students through the interview process. The subjects were chosen from the schools that have won the Golden Hand Award under the category of Computer-Aided Drafting in the Vocational Training Competition for Senior High School Students in the past three years. Five instructors and five awarded students have been chosen as the study samples. Tables 1 and 2 show the backgrounds of the instructors and the awarded students respectively.

Table 1: Backgrounds of the interviewed instructors.

Instructor	School	Dept.	Years of teaching
Li Chien I	The Affiliated Senior Industrial Vocational School of NCUE	Drafting	8
Chen Yen Ming	National Tainan Industrial Vocational School	Drafting	8
Li Chao Yang	National Taichung Industrial Vocational School	Drafting	30
Liao Fu Hsien	National Chia-yi Industrial High School	Drafting	18
Chen Ching Hsuan	National Sha-Lu Industrial Vocational Senior High School	Drafting	18

Table 2: Backgrounds of the interviewed awarded students.

Student	School	Dept.	Year and rank of the awards
Ho Tsung Lin	Affiliated Senior Industrial Vocational School of NCUE	Drafting	No. 4 of the Golden Hand Award, CAD, 2007
Chen Yu Hung	National Tainan Industrial Vocational School	Drafting	No. 1 of the Golden Hand Award, CAD, 2007
Ho Chung Jui	National Taichung Industrial Vocational School	Drafting	No. 3 of the Golden Hand Award, CAD, 2007
Hsieh Chia Cheng	National Chia-yi Industrial High School	Drafting	No. 5 of the Golden Hand Award, CAD, 2007.
Chang Jui Chen	National Sha-Lu Industrial Vocational Senior High School	Drafting	No. 6 of the Golden Hand Award, CAD, 2007

RESULTS AND DISCUSSION

Conducting the learning process depends on the instructors using the correct method, and how they draw and retain the students' attention. As instructors of the participants, they should employ a range of teaching strategies, which is the only way to increase the possibility of the participants winning an award in the competition. The instructors interviewed in this study have outstanding performance in the fields of skill teaching and instruction. During the interview process, their teaching strategies are also made known.

Selection of Participants and Considerations

To select the participants from among the students, the instructor must consider many factors. What kind of students might exhibit outstanding performance in future training? Thus, the participant selection process is also very important. Table 3 includes the interview results of instructors' considerations for participant selection.

Table 3: Instructors' considerations for participant selection.

Instructor	Interview contents
Li Chien I	<ol style="list-style-type: none"> 1. Find out who the special students are in the class, and then select talented ones after a period of training. 2. Screen the initially selected students, remove those who have poor performance from the list. 3. Train four or five participants, test them prior to the competition registration to get the best one to take part in the competition. 4. The first consideration should be an adequate professional capacity, second is the attitude, the attitude will be taken as a very important consideration. 5. Academic capacity is a priority, followed by technical capacity. The primary consideration will be whether he/she can be enrolled into college.

Chen Yen Ming	<ol style="list-style-type: none"> 1. The selection is conducted in the first semester of senior grade two, which is for the preliminary competition. After the preliminary competition, it will be the second round. It does not matter if the students do not win awards in the finals. Once they were able to enter the second round, even if he/she just ranked No.4 or No.5, he/she will be the participant of the industrial-related Computer-Aided Drafting competition for the current year. 2. Observe the drawing abilities of the students in senior grade one to see who has better drawing recognition capabilities, and then find out who are suitable to join the Computer-Aided Drafting and who are suitable to do sketching. 3. When selecting the participant, first consider the technical performance, and then the academic performance. That is enough. 4. Actively encourage the students that the awardees will get guaranteed recommendation and gain more skills, so that the students will take drawing seriously.
Li Chao Yang	<ol style="list-style-type: none"> 1. Select talented students in the second semester of senior grade one who are willing to be trained at night. And, then, select participants in the second semester of senior grade two. The department will select the best ones through a competition. 2. Among the ones with good technical capacity, those who have initiative, high comprehension level, good spatial ability and can follow the instructions well, will be suitable. 3. Require an average or better performance in the fundamental courses, not considering the technical courses. However, those with a high IQ and flexibility will be better. 4. For the students who have ever gained No. 2 in the practical skills programme, and exhibited an average or better performance, their skills will be improved after training. A favourable outcome could be achieved once they are diligent enough.
Liao Fu Hsien	<ol style="list-style-type: none"> 1. Select the candidates and conduct training in the summer vacation of the second semester of senior grade one. Officially select participants in senior grade two. 2. Observe the drawing recognition capabilities, and whether he/she is diligent, responsible and active enough.
Chen Ching Hsuan	<ol style="list-style-type: none"> 1. The teacher can discover who among the students have better spatial ability in senior grade one. Pictorial drawing or supplemental drawing of orthographic projection can help to find out the spatial notion of the students in the first semester of senior grade one. 2. The candidates hand in the required assignments, those who hand in more will be more likely to be selected. The real training starts from the summer vacation of senior grade two. All previous training is done by themselves, not altogether. 3. What is needed is initiative, activeness, high willingness and emotional stability. Those who have bad interpersonal relationships are the last ones to be considered. 4. Despite not being flexible enough, some are still good at learning, but with slow reaction. The primary ones are those who are good at learning and flexible enough. However, diligence can make up for dullness, so diligence with long-time training can bring about the technical progress.

The Individual Characteristics of the Participants

- Individual characteristics of the participants trained by the instructors

Through the training provided by the instructors, the participants can win the Golden Hand Award, each of whom must have some special characteristics. The following discusses the individual characteristics of the participants trained by the instructors (Table 4).

Table 4: Individual characteristics of the participants trained by the instructors.

Instructor	Interview contents
Li Chien I	<ol style="list-style-type: none"> 1. He should be hard-working. The training does not only require drawing, but also include cleaning the work first. 2. The students with a serious attitude but mediocre capabilities will not necessarily lose in the competition, that's because diligence can make up for dullness. Therefore, the difference is quite slight.
Chen Yen Ming	<ol style="list-style-type: none"> 1. He should have initiative and be active, and should ask questions to learn more. 2. Chen Yu Hung has the advantage of carefully listening and thinking, which is worthy of encouraging.
Li Chao Yang	<ol style="list-style-type: none"> 1. Ho Chung Jui has initiative and is active. According to my experience, this kind of characteristics will definitely bring good results. 2. After the practice of orthogonal projection, Ho hardly makes mistakes, and he also has good fundamental capabilities.
Liao Fu Hsien	<ol style="list-style-type: none"> 1. Hsieh Chia Cheng has participated in the national preliminary competition and won fifth place, which made him more confident, and made us examine our weaknesses. 2. The characteristics of a potential winner include being active in learning. He is observant of the objects in the store or components in the car. He also has a high problem-solving capability, and is willing to learn.

Chen Ching Hsuan	<ol style="list-style-type: none"> 1. <i>Chang Jui Chen has a strong thirst for knowledge. When drawing the colour design, he learned from the Internet or DM data, and read some graphic design books. He is emotionally stable and organised.</i> 2. <i>Values and attitude are also very important. For the attitude, some will follow the instruction, but some will not.</i>
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During the interview with the instructors, it was found that the individual characteristics of the participants include initiative, activeness, diligence, organisation, problem-solving capabilities and a good learning attitude. The integration of these factors can make the participants win awards successfully.

- Individual characteristics of the participants

Besides the individual characteristics of the participants required by the instructors, the following are the individual characteristics that were found to be important by the participants themselves. Table 5 presents the interview results of individual characteristics of the participants.

Table 5: Individual characteristics of the participants.

Student	Interview contents
Ho Tsung Lin	<ol style="list-style-type: none"> 1. <i>The participants should ask questions during the drawing process. They should think about it first and ask the teacher. They should also be stress-resistant.</i> 2. <i>I started the training later than others, and I drew very slowly. I paid more attention to the finer points, so my work was more complete than others. As a result, I won.</i>
Chen Yu Hung	<ol style="list-style-type: none"> 1. <i>With a serious learning attitude, I was active and fast in drawing.</i>
Ho Chung Jui	<ol style="list-style-type: none"> 1. <i>In the Department of Drawing, there were three sections, mechanics, engineering and industrial design. I was in the industrial design section, and had learnt the science of colour, so I was well capable of colour dynamics and gloss presentation.</i> 2. <i>When facing difficulties or problems, I tended to solve them directly. I kept alert all the time. Sometimes I review the old drawings, and analyse the mistakes to make sure they would never happen again.</i>
Hsieh Chia Cheng	<ol style="list-style-type: none"> 1. <i>The participants should be patient and calm, and with an inquisitive mind. Ask questions if they have. Active learning is also important, so that the teachers could understand your weakness to make you improve.</i> 2. <i>With much competition experience, I was good at spontaneous response. I thought carefully about whether the visual chart should be removed.</i> 3. <i>I could be faster in the drawing and observing aspects. I think that is my weakness.</i>
Chang Jui Chen	<ol style="list-style-type: none"> 1. <i>I am persistent. All participants want to win, so they seize the opportunities actively, and put all efforts into practice. I drew very slowly, because I did not put too much time into drawing practice.</i> 2. <i>My family does the job of machinery processing, so I can ask my family members or refer to the real objects.</i> 3. <i>I have initiative and am active, and I keep drawing. Once a drawing is finished, I would hand it to the teacher for review.</i>

Each interviewed student was able to analyse his own characteristics. Some think they have a serious learning attitude, initiative and active mind, while some think they are active in problem solving. Others think they are persistent, or difficulty-resistant. These characteristics also allow the students to gain the opportunity of winning awards. However, these are definitely not innate, and the learning process can still change these characteristics.

Teaching Strategies of Instructors

In general, teachers' teaching strategies are related to the learning interest of students and the outcome of the training. The following table lists the teaching strategies used in technical teaching. There are so many methods to instruct students, but it is up to the instructors themselves to choose the most correct or efficient instruction methods they find suitable for the learners. The following discusses the strategies used by the instructors to instruct the students (Table 6).

Table 6: Teaching strategies of the instructors.

Instructor	Interview contents
Li Chien I	<ol style="list-style-type: none"> 1. <i>During the half year before the competition, the participants are required to take part in the training frequently. Most of the training period takes place during the winter and summer vacations, which lasts a long time. There are formal training schedules and simulation tests before the competition. In the last three weeks or even a month before the competition, we conduct the final training.</i> 2. <i>The training of all candidates just expects the students to finish the courses required by the school. We will find out other exercise separately to strengthen our ability.</i> 3. <i>The department training is mainly conducted by the instructors of senior grade three and assisted by</i>

	<p><i>other teachers, all of whom provide support to one another.</i></p> <p><i>4. Make use of the time after class, such as night time or vacation to do further exercise at school. That is because the drawings of the participants are totally different from those of others.</i></p> <p><i>5. The instruction for the participants is mainly practice and examination. Their speed is the first requirement to finish the drawing, followed by the finer points.</i></p>
Chen Yen Ming	<p><i>1. The participants are taught faster while employing the same teaching methods as the other students, and they are made to practice more.</i></p> <p><i>2. Based on the previous annual test of the drawing department, the participants are required to do more practice and finish more simulation tests.</i></p> <p><i>3. The real objects for drawing of the department are enough. I think the participants need to draw more and observe more. If they still cannot understand it, they need to check out the real objects.</i></p> <p><i>4. We keep on gathering topics from past competitions to analyse what is the most suitable for the participants.</i></p> <p><i>5. They are encouraged to familiarise themselves with more shapes and designs of electronic products on the DM for product design. It also depends on the innate talent of the students, which can be hardly achieved through training.</i></p>
Li Chao Yang	<p><i>1. The assignments for the participants are more difficult than that of their other classmates. What they learn is more advanced than level 2. They can accumulate more experience with more drawings and bring about better judgment capabilities.</i></p> <p><i>2. The participant training starts from the easy level, then proceeds to the medium level and advanced level. They are required to practice based on different competition modes, and to also take some simulation tests.</i></p>
Liao Fu Hsien	<p><i>1. During the summer vacation of senior grade one, we first conduct the training through observing and working on the drawings. The drawing part is divided into different levels.</i></p> <p><i>2. They first draw on the topics of level 3, during which they practice 3d, 2d and sketch-based drawing. Beginning from the second semester of senior grade two, they start to practice the engineering drawing of level 2 through conversion from 3d to 2d, followed by the training for the previous competition topics. If they encounter any problems, they are advised to find the real objects.</i></p> <p><i>3. The teaching methods used in the training are greatly different from those used in the class. The training of drawing observation is more intensive. The participants stay at night, or for the weekends or summer and winter vacations for training.</i></p>
Chen Ching Hsuan	<p><i>1. I review their assignments and point out the weakness, arrange practice of more difficult topics, so that their thoughts would be broadened, and they would work faster.</i></p> <p><i>2. They first practice on the topics that are easier than level 3, and then proceed to level 3, then level 2, and then finally the topics of the international talent competitions.</i></p> <p><i>3. There is a slight difference between participant training and common teaching. The participants have a lot of time, so they can be taught through practical experience. The topic needs to be explained for them to know why it is used in this way.</i></p> <p><i>4. There are so many real objects in the Department which aid to clearly, give them an idea of the action or design situation. If there is no real object for the drawing, we can only explain it on the drawing.</i></p>

In order to improve the students' skill learning outcome, the instructors conduct practical sessions before the competition by making use of the time after class, such as at night, weekends and during summer and winter vacations. Moreover, the participants need to apply for vacation leave so they can have time to practice the whole day before the competition, so as to make their skill more proficient. The instruction content is different from general disciplines, and the training material starts from the basic drawing observation practice, then proceeds to the level-3 tests and the level-2 tests, and finally, to the competition topics, including industrial technology arts competitions, national preliminary competition in each district, national final competition and international talent competition. The instructors instruct the students by beginning with the easy level and advancing to the difficult level. There is a great possibility for students with a strong persistence to improve drastically since they will receive greater pressure than the other students. During the skills training process, every school has real objects for reference. If real objects are not available, they can look for similar ones in factories outside. During this process, after seeing the real objects, and getting a detailed explanation from the instructors, the students can have a better understanding of the actual shape, and finally be able to draw working graphics or make a correct assembly. (The teaching strategies when the students receive instruction, to understand the teaching strategies used by the instructors during the training process of the students, are presented in Table 7).

Table 7: The instructors' teaching strategies experience by the students.

Student	Interview contents
Ho Tsung Lin	<p><i>1. The teacher follows a similar path in the training and teaching. At the end of the training, I could draw much faster than the others.</i></p> <p><i>2. I am highly efficient if I learn actively, otherwise, the efficiency is not so good.</i></p>

Chen Yu Hung	<ol style="list-style-type: none"> 1. The teacher's instruction during the training is different from that during the lesson; the training is more difficult. 2. The teacher requires me to keep drawing and performing physical exercises. The physical energy is very important to the participants, because weakness may result in more mistakes. 3. The teacher gives me a set of components for disassembly, and asks me to finish the working drawing for certain components, and then make system graphic, finally make colour presentation.
Ho Chung Jui	<ol style="list-style-type: none"> 1. What the teacher instructs during the training is greatly different from that during the lesson. However, it will not be the case at the end, because the drawing perspectives are there all the same. 2. I am more accurate and faster than other classmates after the training even if the graphic surface is difficult. 3. The teacher shows one example and asks us to imitate it. After that, we find a more efficient and faster method together and compete with each other during the training. In the end, our capacities are all improved.
Hsieh Chia Cheng	<ol style="list-style-type: none"> 1. What the teacher instructs during the training is greatly different from that during the lesson. I learn faster than the others do, and the courses for the competition will not be used in the lesson. 2. The teacher leads the participants to constant training and practice, so he is too busy to see our drawing.
Chang Jui Chen	<ol style="list-style-type: none"> 1. There is a difference between the instructors' training and teaching. The knowledge in the book is compulsory, what I learned is much deeper, like processing. 2. The drawing, if combined with the mechanical view, will let others know what it represents. Those who are good at graphic science are not necessarily good at drawing. 3. See the second assembly graphic. Some have been standardised from which we can judge the real object. So I have quite good spatial ability. 4. The teacher reviews the drawing or discusses with us, who is the final problem-solver. The teacher has much practical experience, so we all hand in our graphics to him for review, and he knows how to define the tolerance.

When instructing students who will be taking part in the competition, the teaching strategy is similar to the teaching content in general courses, but some students think it is different. For the participants, the instructors need to make a deeper and more detailed discussion. As the participants' drawing topics are more difficult than those required in general courses, the instructors will conduct a more detailed explanation after class. In this way, the participants are prepared for the competition topics. The teachers have some practical experience working in factories. Moreover, there are many real objects and components in the department available as teaching aids for the instructors to provide a clearer explanation during teaching or training. With their practical experience in the factory, the instructors have found out the key factors in instructing the students efficiently. The instructors need students who have initiative and are active. The reason is that during the training process, the participants themselves need long-term practice, and should be capable of learning the professional skills in detail. Furthermore, assignments are discussed after the practice, which mainly aims to identify problems and appropriate solutions.

The Learning Process of Awarded Students

Whether the participants can win the awards does not only depend on the individual characteristics, but also the good teaching strategies of the instructors. During the skill learning process, the participants must develop their own learning methods. Table 8 presents the results of the learning process of the awarded students.

Table 8: Learning process of the awarded students.

Student	Interview contents
Ho Tsung Lin	1....During the drawing process, I can find out problems... , and I ask the instructor questions.
Chen Yu Hung	<ol style="list-style-type: none"> 1....I practice at nights, weekends and during summer and winter vacations, ...Since, the second semester of senior grade two, I practiced at school almost every day, 2....It is only after the competition that I started to take the courses required by the curriculum.
Ho Chung Jui	<ol style="list-style-type: none"> 1...., in March or April of senior grade two, the teacher conducted tests to determine who is the final participant. 2....one month before the industrial skills competition, I started on a series of training separately, 3....I practiced at school every Saturday... , every night, ... and during summer and winter vacations.
Hsieh Chia Cheng	1....The teacher found some additional data for us to read and learn, ...in other words, we discover and learn the knowledge of mechanical processing from the training process.
Chang Jui Chen	<ol style="list-style-type: none"> 1. The teacher gave us a lot of data, ...some classmates worked in the factory at that time, so they took some components for drawing, and we also searched for graphics on the Internet. 2....In the second semester of senior grade one, when they drew on topics for level 3, we had already drawn the disassembly of level 2. 3. Compared with The Affiliated Senior Industrial Vocational School of National Changhua University of Education wherein they competed by groups, I competed with myself,....

It can be found from the training process that the basic learning starts from the easier level with repeated practice and constant improvement. Of course, during the learning process, students encounter many difficulties. Students who are persistent to the end can perform better. The interview content also mentions learning with competitors and the schools which conduct training through competition demonstrate superior skills performance. Students make use of nights, weekends and public holidays before the competition for proficiency training. Moreover, during the skill learning process, they have the initiative and are active, and can find out problems and solve them by themselves. As a result, they are able to acquire higher-level skills.

CONCLUSION

Skill learning is influenced by individual cognitive, technical and affective factors. Individuals also have different IQ levels, comprehension abilities, body reaction and motivation, which directly affect the skill learning outcome. A summary of the interviews conducted reveals that the awarded students do not necessarily occupy first place for academic performance during the skill learning process. Some interviewees also stated that during the initial period of skill learning, they were not necessarily the best ones. However, the awarded students stated that they were able to know their technical weaknesses and made up for it during the long-term training, wherein they were also taught to make better use of their time and resources. Only in this way can their skills be greatly improved.

The competition or atmosphere in the learning environment, teaching factors, social and family factors can all affect skill learning. The schools provide the awarded students with a good skill-learning environment, and the instructors actively coach the students. Together with the long-term efforts of the department, these factors combined make for the best learning environment. The recognition and support from the family provide the awarded students with more space for development. The outstanding performance of the seniors, the competition between peers, and communication with the schools make the students understand the technical performance at different levels, and think about their own strengths and weaknesses, which can be used as a reference to further develop their skills.

During the training process, the only way for participants to achieve a more proficient skills level is to implement self-disciplinary measures and try their best to finish the training topics. The participants go through long-term practice, take up both technical and academic courses and experience peer competition. For the instructors, they need to instruct the students about the correct view of drawing, give appropriate direction and plan the correct training pattern, with the goal of further improving the skills of the students. Moreover, the competition may have some unpredictable factors so that the students must be able to handle stress better than others do. Besides, they need to think calmly about appropriate solutions to the problems that arise during the training or competition. If the students can solve problems by themselves, their learning outcome will be much better. Computer-aided drafting places particular emphasis on the abilities of orthographic modelling. During the general learning part, the instructors can judge who is more capable. If the students have good graphic observation and spatial abilities, it may prove to be significant in future training and it allows more space for improvement.

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