Improving the technical skills and desirable characteristics required for mechanical drawing in the automotive parts industry

Suraphan Raksaphramna†, Sumalee Chanchalorb† & Saisuda Pantrakool‡

King Mongkut's University of Technology Thonburi, Bangkok, Thailand†
Suan Dusit University, Bangkok, Thailand‡

ABSTRACT: This research was undertaken to study the problems of acquiring adequate technical skills and the desirable characteristics for producing mechanical drawing in the automotive parts industry in Thailand. The sample group for the study, which numbered 117 persons, consisted of design engineers and owners or managers from the automotive parts manufacturing sector. A mix of quantitative and qualitative method was applied in the study. A questionnaire and an interview were applied as tools. The results have revealed that the design engineers and the owners or managers assigned a relatively high importance to problems of technical skills and qualifications. It was found that, overall, there are several high-level problems with the desirable characteristics required for mechanical drawing. The technical skills level required for the subject matter indicates there are issues to deal with, at a medium level. The conclusion is that by improving training, the workers' technical skills and desirable characteristics would be increased to better match industry demand.

INTRODUCTION

The Auto-Parts Manufacturers Association of Thailand (TAPMA) has determined the qualifications required of design engineers. Workers should possess general technical and soft skills, with applicable specific knowledge and skills [1]. Technical skills refer to the ability to identify and solve engineering problems; soft skills refer to the ability to work in teams and to communicate effectively.

At the present, Thailand is facing the critical issue of skilled workers' shortages and existing mismatch in education in relation to skill demand, especially of those professional workers whose skills are not relevant to the industry

The automotive parts manufacturing industry is an element of the country's automotive industry, with automotive manufacturers outsourcing automotive parts, equipment and tools. There are problems related to the industrial parts manufacturing industry; the inadequacy of production technology; and the import of raw materials and labour shortages, particularly skilled labour and engineers.

The production of automotive components is a linear process, from product design to manufacturing. To ensure high quality and standard of the product, an accurate model design is essential; it enables communication between designers and manufacturers. One of the most important factors is a drawing that contains accurate information including shape, size and properties of the product as needed for production [2]. A not-exhaustive, imprecise drawing will be detrimental to production of the required quality and standard.

At present, the designers are using two-dimensional (2D) and three-dimensional (3D) design software for parts and motion stimulation. The software assists in drawing, and also provides information for the production process [3], making the work faster, more precise and less error-prone.

However, there are problems:

- how to select the right software for a job or product;
- lack of software knowledge and skills;
- lack of technical drawing skills and comprehension.

The problems are rooted in the education system not teaching the technical skills to meet the needs of the automotive parts manufacturing industry [4]. Accordingly, this research was carried out to study the problems of the design engineer using CAD in the automotive parts manufacturing industry. The aim is to improve the training of design engineers to meet the needs of the automotive parts manufacturing industry.

TECHNICAL SKILLS IN DESIGN ENGINEERING

Technical skills refer to capabilities that can be learned and are relatively easy to measure, such as the application of software. These skills are connected to cognitive intelligence, and relate to the ability to perform a particular type of activity or task [5].

In engineering/technology, technical skills include the ability to:

- apply the knowledge and skills of engineering/technology;
- identify and solve engineering/technology problems;
- conduct experiments/standard tests and to analyse the results;
- identify and use technical literature [6].

Traditionally, the above are the focus of engineering and technology programmes.

RESEARCH GOAL AND METHODOLOGY

The technical skills and desirable characteristics for mechanical drawing in the automotive parts industry were examined in this study. The respondents numbered 117. All use CAD programs. Quantitative and qualitative questionnaires and interviews were applied in this study. The design engineers, owners or managers completed an anonymous closed questionnaire for evaluating problems and the need for technical skills.

Semi-structured interviews were held with 30 owners or managers, to broaden the information gleaned from the questionnaire. Then, they were asked to evaluate each skill level; each expert took approximately two to four hours. The quantitative data were statistically analysed, and the qualitative data underwent content analysis performed by two engineering education experts. Only information obtained from at least three different participants was included in the analysis.

A five-level Likert scale, ranging between strongly agree and strongly disagree was included in the questionnaire to determine the skills required and desirable characteristics. The questionnaire was sub-divided into four sections. The first section covered the general background of correspondents. The other three sections covered the technical skills and desirable characteristics required by mechanical drawing with CAD. The latter involve competency referring to courses provided by vocational institutes and national skill standards of mechanical computer-aided drawing [7].

The questionnaire was validated by two engineering education experts and three design engineers who did not take part in the study. Cronbach's alpha was 0.91, indicating acceptable internal consistency.

In the interviews, the participants were asked, *inter alia*, what were the most important technical and soft skills for mechanical drawing, and whether there was sufficient emphasis on those skills.

FINDINGS

The majority of respondents were male (90.6%), with an age between 31-45 years (52.1%), with work experience between 5-10 years (37.6%). These statistics are shown below in Table 1.

Table 1: General information.

General information		Number (n = 117)	Percentage (%)
Sex	Male	106	90.6
	Female	11	9.4
Age	More than 46 years	9	7.7
	31-45 years	61	52.1
	Less than 30 years	47	40.2
Work experience	More than 11 years	29	24.8
	5-10 years	44	37.6
	Less than 5 years	44	37.6

The results of the study of industry opinions about technical skills for mechanical drawing with CAD are shown in Table 2 (using the mean (M) and standard deviation (SD)).

Table 2: Problems with technical skills for mechanical drawing using CAD.

Scale	Sub-scale	M	SD
Basic skills	Computer	3.17	0.79
	Drawing by instruments	3.07	0.94
	Reading drawings	2.98	0.96
	Measuring with instruments	2.76	0.87
Drawing with CAD	2D drawings	2.97	0.94
	3D drawings	3.09	0.97
	Welding and symbols	3.29	0.93
	Pipe and symbols	3.28	0.94
	Gear and symbols	3.35	0.86
	Spreadsheet	3.43	0.83
Checking and analysing	Checking the accuracy of a print job	3.13	0.89
	Analysing and defining tolerances of the parts assembled	3.49	0.81
Applied and machine design	Designing a four-bar mechanism, a Geneva gear and cam	3.56	0.88
	Designing mechanisms of linear and angular motions	3.52	0.88
	Motion simulation, collision checking of pieces with CAD	3.63	0.80
	Connecting parts designed to work with the engineering analysis	3.70	0.81
Total		3.20	0.53

The biggest problems were:

- connecting parts according to the engineering analysis;
- motion simulation and collision detection using CAD;
- designing four-bar mechanisms;
- Geneva gear and cam;
- mechanisms for linear and angular motion.

The least problem was measuring with instruments.

Desirable Characteristics

The result of expert interviews and the analysis of data from the reviewers identified 12 desirable characteristics for mechanical drawing with CAD and they and their ratings as shown in Table 3.

Table 3: Desirable characteristics for mechanical drawing with CAD.

Desirable characteristics	M	SD
1. Willingness to work	3.62	0.92
2. Honesty	3.43	1.12
3. Punctuality	3.48	1.17
4. Effective use of material	3.90	1.04
5. Good working relationships	3.38	1.12
6. Analytical	3.76	0.83
7. Problem-solving and decision-making	3.43	0.87
8. Provides support and guidance to subordinates	3.29	0.85
9. Accepts the ideas of work colleagues	3.24	1.04
10. Analysis and planning	3.76	1.00
11. Resolves issues taking into account efficiency and effectiveness of the work	3.48	0.81
12. Adapts to the development of knowledge. Accepts accumulated knowledge, expertise and experience of others	3.62	1.02
Total	3.53	0.83

From Table 3, desirable characteristics for mechanical design with CAD was high for 5 of the 12 items. Effective use of material was the first desirable characteristic; analytical, analysis and planning were the second required characteristics; and then, adapts to the development of knowledge, etc (M = 3.62). The other items (7 of 12) had an M = 3.48 to 3.24. As a whole, these characteristics were highly desirable (M = 3.53).

DISCUSSION AND CONCLUSIONS

According to the findings on the problems of mechanical drawing with CAD, basic skills, drawing with CAD, checking and analysing were problems at a moderate level. However, computer skills were a greater problem than any other; spreadsheet skill was higher than any other problem for drawing with CAD; analysing and defining tolerances of parts

assembled was also a significant issue. These skills should be addressed and practised more in mechanical drawing programmes [8].

Applied and machine design were rated as a high level problem, especially on connecting parts designed to work according to an engineering analysis, which was rated the greatest problem. Thus, this should be of concern in a mechanical drawing programme. Both public and private educational institutions involved with skill development and training should develop and enhance the quality of their training courses. Furthermore, this can be achieved by re-designing learning in accordance with the needs of employment.

Regarding desirable characteristics: essential general behaviour included willingness to work and saving material (Table 3 - items 1 and 4); being analytical with good analysis and planning (Table 3 - items 6 and 10); and adapts to the development of knowledge, accepts accumulated knowledge, expertise and experience of others (Table 3 - item 12). Therefore, training should also focus on strengthening and developing these desirable work characteristics.

Workers in the automotive part manufacturing industry tend to economise on material costs as the number one objective because of the effect on production cost, efficiency, environmental impact and resource utilisation. Therefore, training should cultivate the workers' habit to plan the economical use of material. Also, workers should be trained to be able to analyse jobs and plan the progression of the work.

Moving on to the skills of mechanical drawing with CAD, the findings from the study were that applied and machine design is rated with the highest. The mechanical drawers must have a good understanding of this, to design and draw better. Thus, the training programme should extensively cover design and application solutions to meet industry demand [4].

In applied machine design, the highest-level problem was connecting parts involved in the design and creation of automotive parts, based on engineering analysis. Secondly, there were problems with designing four-bar mechanisms, Geneva gears and cams. Thirdly, there are issues with motion simulation relating to collision detection of components using CAD, and the last problem was designing a linear and angular motion mechanism. Training courses should pay more attention to basic mechanical and motion design knowledge. These areas need to be well studied, to create drawings correctly.

In conclusion, the study was useful in that it could guide the training of design engineers and workers in mechanical drawing with CAD in the automotive parts manufacturing industry in Thailand. Improved training would increase these workers' technical skills and desirable characteristics to better match industry demand.

REFERENCES

1. Itani, M. and Srour, I., Engineering students' perceptions of soft skills, industry expectations, and career aspirations. *J. of Prof. Issues in Engng. Educ. and Prac.*, 142, **1**, 04015005 (2016).
2. Murat, Y. and Birsen, K., Developing innovation applications of technical drawing course at the maritime education. *Procedia-Social and Behavioral Sciences*, 195, **2515**, 2813-2821 (2015).
3. Huang, R., Zhang, S., Bai, X., Xu, C. and Huang, B., An effective subpart retrieval approach of 3D CAD model for manufacturing process reuse. *Computers in Industry*, 67, 38-53 (2015).
4. Kfir, C. and Reuven, K., Teaching mechanical design practice in academia. *Procedia CIRP*, 36, 177-181 (2015).
5. Gero, A. and Mano-Israeli, S., Importance of technical and soft skills: electronics students' and teachers' perspectives. *Global J. of Engng. Educ.,* 22, **1**, 13-19 (2020).
6. Accreditation Board for Engineering and Technology. Criteria for Accrediting Engineering Programs. ABET (2018).
7. Department of Skill Development. Announce of Committee Promoting the Development of Skilled Labor National Skill Standard of Mechanical Drawing with Computer Aided Design (CAD). *Government Gazette*, 128, **81**, 61-64. (2011).
8. Vargas-Mendoza, L., Gallardo-Córdova, K. and Gómez-Muñoz, J.L., A learning environment to stimulate the development of competencies for mechanical design. *Global J. of Engng. Educ.,* 21, **1**, 84-90 (2019).

BIOGRAPHIES

Suraphan Raksaphramn is a PhD candidate in the Learning Innovation and Technology Programme in the Faculty of Industrial Education and Technology at King Mongkut's University of Technology Thonburi (KMUTT), Bangkok, Thailand. His educational background is in industrial engineering and industrial education (production engineering).

Associate Professor Sumalee Chanchalor obtained her PhD in curriculum research and development from Srinakharinwirot University, Thailand. At present, she is a lecturer in the Department of Electrical Technology Education, Faculty of Industrial Education and Technology, King Mongkut's University of Technology Thonburi, Bangkok, Thailand.

72

Assistant Professor Saisuda Pantrakool obtained her PhD from the learning innovation and technology programme in King Mongkut's University of Technology Thonburi, Thailand. At present, she is a lecturer in the Library and Information Science Programme, Faculty of Humanities and Social Sciences, Suan Dusit Rajabhat University, Thailand.