

# DEVELOPING A TEACHING FACTORY LEARNING MODEL TO IMPROVE PRODUCTION COMPETENCIES AMONG MECHANICAL ENGINEERING STUDENTS IN A VOCATIONAL SENIOR HIGH SCHOOL

**Dadang Hidayat Martawijaya**  
Departement of Mechanical Engineering  
Indonesia University of Education  
Jl. Dr. Setiabudhi No. 229 Bandung 40154, Indonesia  
Email: [dadongupi@yahoo.co.id](mailto:dadongupi@yahoo.co.id)

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## ***ABSTRACT***

*The purpose of this study is to develop a learning model that can provide vocational senior high school students with an authentic industrial working experience in the manufacturing and production sector in the very same school that they are enrolled. An appropriate in-school industrial experience is expected to improve students' competences and skills. A four stage research and development method was used, involving preliminary study, development, testing and model validation. The study uses both qualitative and quantitative analysis techniques to produce a six steps teaching factory learning model (TF-6M Model). Data was gathered from teachers (n= 8) of a school in Indonesia and students of class XI (n=132) who formed the experimental and the control groups in the model validation stage, and student of class XII for the preliminary study (n=35) and development test (n=98). The focus group discussion (FGD) reveals that the production teacher believes that the TF-6M model can be used to improve students' competences. Data from students shows that TF-6M Model increases students' competences, is preferred by students, increases their time spent at work, and improves their soft and hard skills, motivation, sense of responsibility and work ethics.*

***Keywords:*** *teaching factory model TF-6M, students competencies, Vocational Senior High Schools*

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## 1. INTRODUCTION

The development of information, science and technology has accelerated the dynamics of development policies in education. *Sekolah Menengah Kejuruan (SMK)* or Vocational Senior High School as a sub-system of the Indonesian education system has to adapt to improve the quality and outcome of education. Graduates need to be well prepared for the world of industry as well as entrepreneurship, as stated in the Law of Republic Indonesia number 20/2003 article 18 and the explanation of article 15 concerning the regulation of vocational high schools. Vocational high schools were established with the aim, among others, to prepare learners to be able to work, either independently or to fill existing job vacancies in the world of business and industry as middle-level manpower, especially in the related fields and skills/expertise that interest students. These schools also aim to equip students with the capabilities to choose a suitable career and with tenacity, persistence and competitiveness to develop a professional attitude in their areas of interest and expertise. These two objectives would greatly contribute towards improving the quality of graduates that will in turn improve national income and productivity and improve the country's ability to anticipate the impact of global changes.

*Lembaga Ilmu Pengetahuan Indonesia (LIPI)* reported that majority of SMK graduates were unable to adapt to changes in science and technology and to empower themselves. They were also hard to retrain (as stated in the SMK curriculum year 2004). In addition, the report indicated that the learning process in SMK neither touched nor developed the required adaptive skills and capabilities. To this end, an improvement in the quantity and quality of technical and vocational education in Indonesia is imperative (Suranto, 2005), and this is indeed a great challenge.

In facing this challenge, the Indonesian government took strategic steps towards better access and distribution of education at the national level. *Badan Standard Nasional Pendidikan (BSNP)*, the body responsible for standards, launched eight standards to improve the education system through Government Rule Number 19 in 2005 (PP19/2005). The Strategic Plan of National Education Department in 2005 also stated that the required proportion of SMK and *Sekolah Menengah Atas*, or Senior High School (SMA) to reach 70:30 by 2015. The development of the Curriculum at School Level (KTSP) was another endeavor, launched in 2006. KTSP was an operational curriculum, designed and implemented at each level of formal schooling. It projected that 20% of its graduates to involve in entrepreneurship, 50% to work nationally, 10% to work abroad and 10% continue to university.

Innovation in education has led to the development of life skills, using integrated learning and contextual teaching and learning models. Both learning models have a similar aim of developing students' life skills. The government also planned for an SMK-based industrial program, '*Program Industri Berbasis SMK*' to improve economic growth at provincial level through the Manufacturing Industry Teaching Model. Six objectives of the program are (i) to support local economic growth, (ii) to enhance the job market, (iii) to generate national products at low cost (iv) to increase domestic flow of rupiah (the Multiplier Effect) (v) to improve the quality of national human resources and (vi) to improve Indonesia's economic status. By empowering the SMKs and facilitating their cooperation with industries, SMKs produced useful machine tools for the target schools and market. The total number of required machine tools is 91.260 units, whereas the assembling capacity of 10 SMKs is 1.920 units per year. If SMKs are supported with 35 units of machine tools, 55 SMKs per year would be equipped with standardized practicum facilities.

Availability of standards and effective and efficient use of the facilities have provided students with optimum support in developing their competencies. Results of past research suggest

that students who obtained industrial work experience through ppracticum in schools have higher competencies than their peers who are placed in industries. In-school practicum students are also able to develop their career either locally or abroad (Martawijaya: 2010). It suggests schools that implement better industrial experience programs to simulate a real working environment produce students with real experience and better skills and expertise.

Adopting the teaching factory learning model into integrated learning in the form of production based learning (PBL) will equip students with valuable experience from learning by doing, relevant to a worker's roles in a factory/ industry. The experience gained whether in hard (vocational and academic) or soft (personal and social) skills will develop their competencies in these four aspects.

A new learning model needs to be developed to address the challenges laid out at the beginning of this section. Five research questions were formulated in developing and validating the model. The questions are as follows:

- a. How were production courses taught in Vocational High Schools in Bandung?
- b. How would a learning model design which provides direct experience and creates industrial work atmosphere within the school setting, especially in production courses, improve mechanical engineering students' competencies?
- c. What are the implementation methods of the learning model which provides direct experience and creates industrial work atmosphere within the school setting, especially in production courses in mechanical engineering that would improve the students' competencies?
- d. What are the supporting factors and barriers in implementing a learning model that would improve the students' competencies by providing direct experience in a real industry within the school setting, especially in production courses in mechanical engineering?
- e. How effective is the learning model, which provides direct experience in a real industry within the school setting especially in production courses in mechanical engineering, in improving the students' competencies?

## **2. RESEARCH METHODS**

The model was developed using research and development (R&D) method. According to Gall, Gall, and Borg (2003), this method is suitable to enhance a product. The product, (learning model, in this case) will be well validated because it goes through many series of trial steps to confirm its effectiveness. These trial steps are indicated in Figure 1 (Gall, Gall, and Borg (2003)).

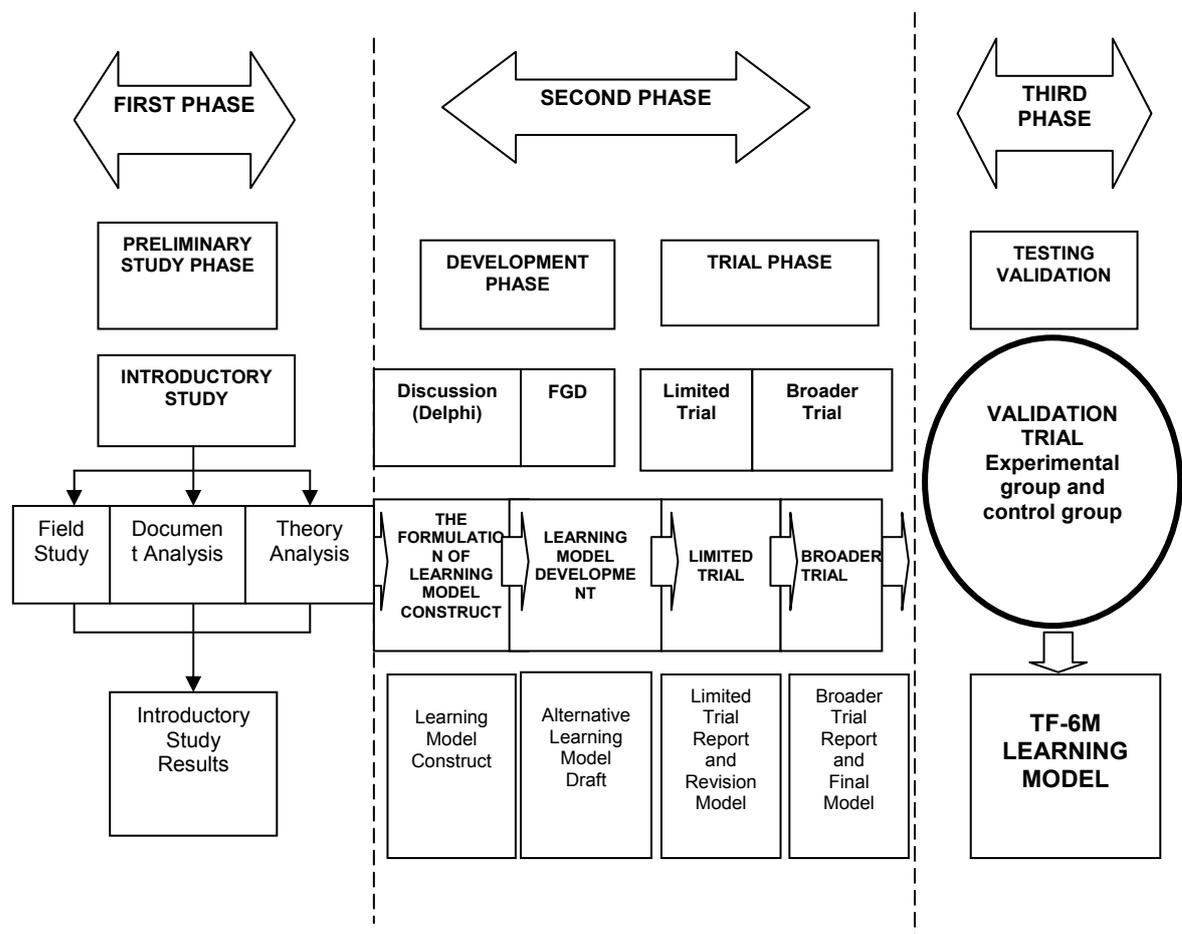


Figure 1: Steps in the R&D of the Learning Model

Data for model development was gathered from students in class XII for the preliminary study (n=35) and the development test (n=98). Based on the draft model, further information was gathered during the focus group discussion (FGD). The productive course teachers (n=8) in the FGD said that the TF-6M model can be applied to improve students' competence. Finally, the model was validated using students in class XI (n=132) from a school in Indonesia. They were divided into an experimental group (n=65) and a control group (n=67).

## 2.1 The Learning Model Design

The learning model is explained in detail in the following section.

### a. Name of Model:

The Six Steps Teaching Factory Learning Program Model or the 6M-Teaching Factory Learning Model (TF-6M Model).

**b. Purpose of the Learning Model:**

To increase the competencies of students' that enrolled in productive courses in the Expertise Competence in Mechanical Engineering program, by promoting social relationship in an industrial atmosphere within schools.

**c. Learning Materials:**

- 1) Replacing school's management with industrial management. Materials include (1) rationale – why a change in management is required, (2) general description of the world of industry, (3) description of SMK graduates' positions in the industry, (4) description of a junior technician's competences, (5) job assessment system in the industry, and (6) discipline, labor ethics and productivity.
- 2) Communication skills, which include (1) what communication is, (2) importance of communication to a junior technician, (3) examples of successful communications, (4) good communication by using good intonation, suitable expression and accurate body language, (5) practice good communication skills.
- 3) Analysis and response to orders, that include: (1) interpreting pictures, (2) working with general machines, (3) selecting suitable machines, chopping tools and working time to correspond with work materials, (4) selecting measurement and hand tools, (5) steps in quality control (6) work safety provisions , and (7) operating machines.

**d. Learning Activities:**

Activities in TF-6M Model require the following preparations: administrative preparations, training subjects, provision of materials, ingredients, machines and tools, and a lesson plan. These preparations are followed by 3 major phases: Introductory, Main and Evaluation:

**1) Implementation of Preparatory Activities:**

- a) Convincing students to agree to replace the school management with an industrial management system. Teachers and students discuss, propose some arguments, and finally agree to the alternative model (TF-6M Model).
- b) Explaining what communication skill development entails by presenting relevant case studies as examples of effective communication and training the students to communicate well and practicing effective communication skills in receiving orders from the instructor, in stating their readiness to execute the orders, and in delivering the results to the instructor.
- c) Guiding the students to interpret pictures, to determine the required materials, machines, chopping tools and machine speed, to count time, price, and to practice work safety procedures (practicing to analyze orders)

## 2) The Implementation Scheme

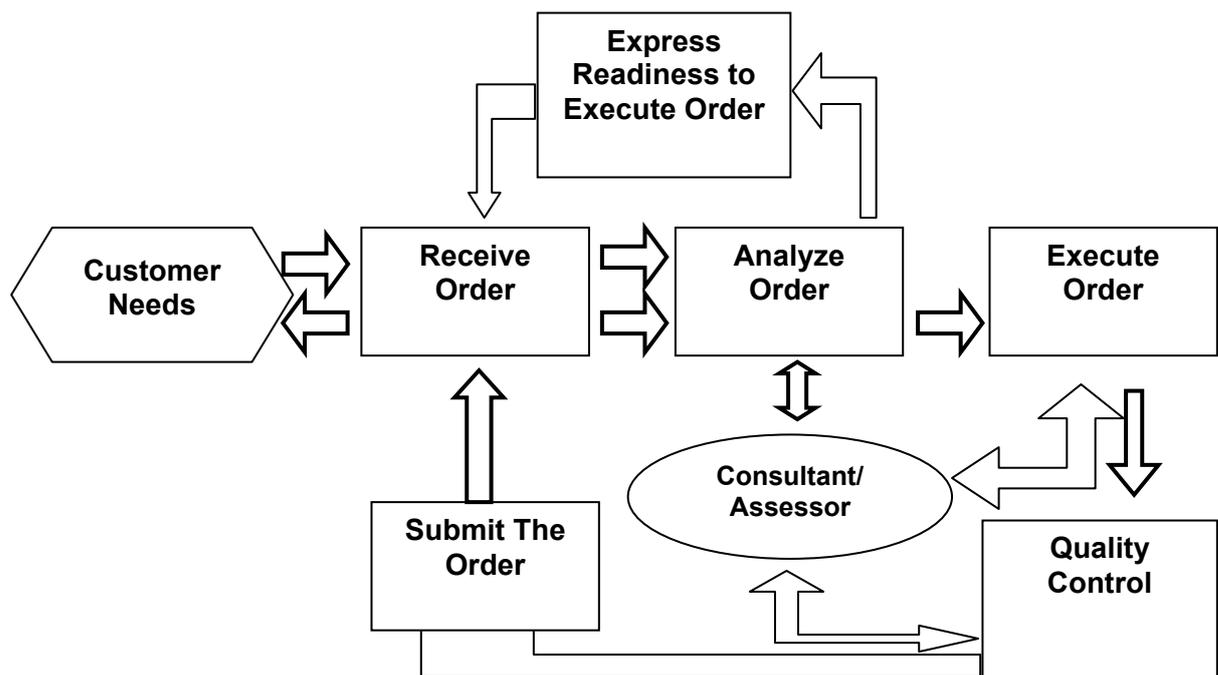


Figure 2. The Scheme of TF-6M Model

## 3) Main Activity

### a) Introductory Phase

- i. Step 1. Students engage in role playing, acting as workers who receive orders using effective communication with good intonation, expression and body language.
- ii. Step 2. Students analyze orders by interpreting the picture and determining the required materials, machines, chopping tools, centrifugal machine, time, price, and work safety practices. During the training, students refer frequently to the consultant.
- iii. Step 3. Using the results of their analysis, students are confident and ready to execute the orders and to express themselves using good communication skills.

### b) Main Phase

- i. Step 4. Execute the orders by adhering to work safety procedures, undertaking preparatory work, implementing the working procedures in line with the Standard Operating Procedure, appraising the value of work, calculating the time, and seeking advice from the consultant.
- ii. Step 5. Apply quality control by fitting the sizes, comparing the level of precision and function with the requirement and seeking advice from the consultant.
- iii. Step 6. Communicate well, submit the results, request feedback from instructor and maintain good communication with the instructor.

**c) Closing Phase /Evaluation Phase**

Teachers as consultants and assessors in charge of the whole learning process observe and evaluate the whole learning process. This includes the results and the learning program.

**3. RESULTS AND DISCUSSION OF RESEARCH**

The model was validated by comparing the achievements (vocational and soft skills) of the experimental group of students (n=65) who used the TF-6M method with the control group of students who used conventional methods (n=67). Data in the TF-6M model validation test is shown in Table 1.

**Table 1. The TF-6M Model Validation Test Data**

No	Aspects observed	Experimental Group	Control Group
1.	Cognitive Competence		
	a. Average	0,7746	0,3042
	b. Interval (95%)	0,6987 - 0,7942	0,2676- 0,3408
	c. Median	0,8001	0,2858
	d. Ranks	E > K (significant)	K < E (significant)
2.	The Order 1,2,3 of Vocational Competences	71,63	42,30
	a. The average score of order 1,2,3	70,69 – 72,56	41,85 – 42,76
	b. Interval (95%)	70,48	41,90
	c. Median	E > K (significant)	K < E (significant)
	d. Ranks		
4	Students' Perception:		
	a. Conventional Model		
	1) Pre Test	79,11	74,92
	2)Post Test	71,88	77,54
	b. TF-6M Model	89,44	-----
5.	Students' workshop attendance		
	a. Start working	6.50 < 7.00	K ≥ 7.00
	b. Finish working	14.03 > 13.00	K < 13.00
	c. Work duration	7.08 > 6.00	K < 6.00
6	Increase in students' soft skills through the TF-6M Model	58,92% Significance (mediocre)	-----
7	Increase in students' hard skills through the TF-6M Model	77,99% Significance (high)	-----
8	Others :		
	a. Motivation to achieve	High	Low
	b. Sense of responsibility	High	Low
	c. Work ethics	High	Low

Data in table 1 indicates that compared to students in the control group, students in the experimental group;

- i. obtain higher cognitive competence scores
- ii. obtain higher competence scores for orders 1, 2 and 3
- iii. have less favorable perception of the conventional approach;
- iv. spend longer duration on their work in the workshop;
- v. score higher on soft skills;
- vi. score higher on hard skills;
- vii. have better motivation, sense of responsibility and work ethics.

### 3.1 DISCUSSION OF RESEARCH

The TF-6M Model's usefulness in improving students' cognitive and vocational competencies facilitates SMK graduates in obtaining a workforce certification of competence that matches the BSNP (PP23/2004) standards. This meets one of the policy requirements that is essential for graduates' job placement prospects – students not only have to pass the national final examination, they are also required to sit for a competence examination (Directorate General for Primary and Secondary Education: Dirjen Dikdasmen, 1999).

The TF-6M model also improves students' soft and hard skills. It follows the *work-based learning* concept and meets the needs of students and their work places. It increases students' competencies and prepares them for future challenges. To equip students with learning experience, skills and readiness to work, learning has to be individually and comprehensively designed (Boud, 2003). The integration of soft and hard skills in the TF-6M Model is also in line with the learning factory, which regards learning as a set of intellectual and physical activities in a series of theoretical framework units and real field practicum, integrated in the manufacturing process (Jorgensen, Lamancusa, Zayas-Castro, and Ratner, 1995).

In line with Barlow's learning factory (1974) and the seven principles of vocational education, integrating theory into practice and involving the instructor in a trust-relationship program will equip students with comprehensive competencies that would manifest in the form of actual abilities (Anderson, 2002).

Furthermore, the TF-6M Model integrates soft and hard skills in accordance with the development of learning activities. These activities are designed to expose students with direct experience involving both mental and physical processes through interactions with teachers, other students and facilities to achieve basic standard competences. Learning activities include life skills that students should master – students should not be taught in just substance (subject matter) but they should also be equipped with generic / soft skills. (Direktorat PSMK, 2008).

The TF-6M Model is also useful to improve students' motivation, sense of responsibility as well as work ethics. It is closely related to the social functions of education: imparting skills, transmitting cultures, adapting to the environment, maintaining discipline and building ethical behavior (Calhoun, Light and Keller: 1997). The model is also in harmony with the teaching and learning principles in vocational education. These principles encourage students to pursue a career that meets workforce needs and emphasizes safety in the workplace (Miller, 1985). In addition, the TF-6M model builds students' work ethics in line with the purpose of industrial training and the needs of the workplace (Direktorat PSMK, 2008). In fact, because it offers students a real, field work experience and forms integrative and meaningful competencies, it can arguably replace the functions of industrial training.

The model validation test suggests the following:

- i. Education in SMK should be holistically organized so that all aspects of students' potential can be well developed;
- ii. Students should be trained in knowledge construction to develop constructive thinking abilities;
- iii. Education in SMK should not limit its focus on vocational competence. It should also consider other aspects such as academic, personal and social;
- iv. Contextualized learning is an appropriate learning approach to be implemented in teaching and learning processes in SMK;
- v. Contextualized learning in SMK can be created through learning by doing in a real job;
- vi. Industrial atmosphere is not only available in workplaces – it can also be created within a school setting;
- vii. Industrial atmosphere within a school can be created by replicating an industrial site plan in the workshop. In addition, the relationship between a teacher and a student should extend beyond knowledge transfer. Teachers should also play a role as consultants and assessors, and students as workers in an industry;
- viii. The assessment approach in the abovementioned teacher-student relationship is not based on Norm Reference Assessment. Instead, it is based on Criterion Reference Assessment using 'go-no-go' strategies that meet industrial standards.

The TF-6M model promotes the idea of replicating real world industrial experience within a school setting in time blocks. It was effectively carried out in schools and improved students' productive competences.

### **3.2 IMPLICATIONS OF THE MODEL**

The TF-6M Model Learning Program consists of six steps in each work cycle. The steps are (1) receive the given order, (2) analyze the order, (3) express the readiness to execute the order, (4) execute the order, (5) incorporate quality control and (6) submit the order.

Soft and hard skills are embedded in the TF-6M model. Activities in the model are expected to develop students' potential with regards to personal, social, academic and vocational capacity in an integrated manner in every learning cycle. There are three actors in a learning process, (i) students as workers, (ii) teachers as assessors, consultants and facilitators in charge of the whole learning process, and (iii) the instructor (consumer) either from the industry or the private sector or from within the schools.

- i. In the first step of receiving the order from the instructor, activities are performed using effective and meaningful communication with the students as order recipients. Instructor and order recipients develop mutual trust, which in turn promote mutual understanding and benefits.
- ii. In the next step of analyzing the order, students analyze orders received from the instructor in a pictorial form. Workers are required to immediately state their readiness in executing the order within a specified time frame, so responding to the request requires a high confidence level. Students should be equipped with knowledge and skills to analyze the orders. Students should also refer to the teachers who are acting as consultants.
- iii. In the next step of stating readiness to respond to the order, students effectively communicate their readiness to execute the order as specified. This may take place even

- when students are unsure of what they should do. Once the students are ready to respond, they will arrange for appointments. This step requires a high level of commitment and develops students' motivation, sense of responsibility and work ethics.
- iv. The next step of executing the order involves students starting work according to the specified order. Adhering to safety regulations and work procedures is imperative to produce a high quality product as specified by the order.
  - v. In the step of quality control, students appraise their products by carefully comparing them against the orders. This step requires trust and carefulness. At the end of this step, the students provide assurance that their products complied with the specified orders.
  - vi. In the final step of submitting the order, students, again, practice effective communication. They should be confident that the products are acceptable to the instructor because they complied with the specified orders.

#### 4. CONCLUSION, IMPLICATION AND RECOMMENDATIONS

In summary, the data supports the following conclusions. First, the TF-6M model can effectively improve students' productive competencies, both cognitively and vocationally.

Second, several pre-requisites must be in place to ensure a smooth implementation of the TF-6M model. They are (i) an agreement based on an understanding between teachers and students to adopt industrial management practices to replace the existing school management practices, (ii) policy support from the headmasters, (iii) procurement of standardized practicum facilities, and (iv) sufficient allocation of time blocks.

Third, meeting the four requirements above enables a well implementation of the TF-6M model. The model provides students with direct exposure to the industrial world within a school setting and develops their attributes and skills that should be found in a competent industrial worker. It also comprehensively builds their personal, social, cognitive/academic and vocational competencies and instills good motivation, sense of responsibility and work ethics. Furthermore, the model enables a comprehensive industrial practicum to be implemented within a school setting, integrated with the Competence Test System.

Fourthly, several policies should support the TF-6M Model. These policies are the PP-19/2005 (the Government Regulation) which has been gradually implemented and the Local/Regional Autonomy which is already underway. Other significant innovations include KTSP, Schools with Excellent Qualities (*Sekolah Unggulan*) and International Based Schools (*Rintisan Sekolah Bertaraf Internasional*). Teaching Factory is currently in the pipeline. Some schools require the headmaster to change their policies. For example, additional steps were undertaken in SMKN 6 Bandung. The structure and infrastructure of practicum facilities were standardized and teachers were certified as assessors. Teachers of production courses, as civil servants, must be highly committed. In addition, industry practitioners should be highly committed as role models of good work ethics.

Policy and practical factors may hinder the implementation of the TF-6M model. On the policy side, PP19/2005 has not been fully implemented. Policies remain centralized (local/regional autonomy has not been smoothly implemented) and recognition from policy makers remains absent.

On the practical side, limited provision of materials/ingredients for practicum, difficulties in convincing the customers to order products and assuring them of students' work quality, too few teachers resulting in a high student-teacher ratio and difficulties in developing a teacher-made unit lesson plan are among the barriers. Also, incorporating incoming orders into the design is challenging, and so is building an agreement to replace the school management with an industrial management system. Finally, training students with communication skills is not easy.

In short, the implementation of the TF-6M Model requires an agreement between teachers and students, support from the headmaster, standardized practicum facilities and sufficient blocks of time. Changes in the school environment from a traditional school management to an industrial management system are required as the TF-6M Model should provide students with a direct experience of the industry within a school setting.

As mentioned above, a smooth implementation of the TF-6M Model requires support from all related parties, from teachers of the production courses who would implement this model as an alternative to traditional learning models of producing industrial products, to the headmasters who would undertake the model's implementation strategies, which consist of:

- (i) empowering professional teachers to create an industrial atmosphere in schools by positioning students as junior technicians and using all available facilities to expose students with as much experience as possible
- (ii) supporting professional teachers to create marketable orders that can be executed by the students
- (iii) motivating production course teachers to develop students' academic, vocational, personal and social competences because these can reinforce students' motivation, sense of responsibility and work ethics.
- (iv) promoting the TF-6M Model to be rolled out both through in-school practicum and in industrial fields with the support from the Directorate of SMK Development Management that would enable this model to be adopted in all national schools.

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