



# Improvement of Welding Skill Using Competence Based Education and Training (CBET) Method

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**Abstract.** Batam is the growing industrial island in the province of Kepulauan Riau, its advancing improvement technology especially in the welding industry causes more structural steel and shipyard companies are struggling to get more welders or welding operators in this region. Currently workers with welding skills are in demand especially in Batam Island. There are many fabrications as well as shipyard companies whether in Batam or its neighbouring islands such as Bintan and Karimun, many are looking for the workers with this skill. To satisfy this current need, there are many vocational schools in Batam which are developing their welding training facilities for the improvement of their students' welding skill, and among others are using dual learning of both national and international skill-based competencies, where national scheme welding competency is Welding National Competence Standard (Per Men Nomor 98 Tahun 2018) and international scheme of ISO 9606-1 and IIW. This research is based on experimental research which using Borg and Gall improvement technique using dual competency-based education and training (CBET), the vocational high school students in Batam will understand both national and international requirements of welding skill and techniques. The program by combining both national and international scheme, will give full benefit for the students the chances to be hired by either national or international companies which recognize the skill competencies in their line of works. The outcome or results of the research shows that the program enables the students to be entitled as specialized coded welders recognized by both international companies and national enterprises in Batam.

**Keywords:** CBET · Welding Skill · Vocational Schools

## 1 Introduction

Batam and its majoring neighbour islands like Bintan and Karimun are within the proximity of Singapore Cosmopolitan country and an island with total population of 10 million people, compared to Batam which is populated by approximately 2 million people and about 25,000 people working in metals fabrication sectors. Industries are among

the popular attributed to Batam island which is very attractive in becoming working people destiny and harbour [1].

The problems which are faced by most welding related companies in Batam, that the students who were trained as welders are not ready to work in their work field due to the welders were not qualified up the companies' standards or qualifications which mostly referred to European standards (ISO). Every day work is becoming more competitive where company recruitment system will be based on either experience or competencies of the workers. This rivalry behaviour tends to demand our workers to be fully equipped with such competencies and talents, and welding skills are among others which are quite demanded nowadays in this region [2]. Welding is the art to coalescence of two materials or metals, either the same or dissimilar, into one structure using either heat or pressure, with the help of gas or not [3].

The definition of welder as per ISO 9606-1 is a person who holds and manipulates the electrode holder, welding torch or blowpipe by hand [5]. Many students vocational high school are attracted to master this skill, and many tried hard to obtain more advanced welding skill such as semi-mechanized or mechanized processes [6]. The intent of this research is that the education and training materials shall include relevant and outstanding welding qualifications standards which are recognized by many companies in Asia, Africa, and Europe. This also becomes solution to the vocational schools where their students can be more ready to compete in both national and international regions.

### 1.1 Local Rules and Regulations

Indonesian Government has issued many regulations to administer the workers or students who will be involved in the working conditions, all these regulations will protect our workers or welders to have safe working environment as well as rights to have proper knowledge and skills at their workplace. Government Regulation such as Constitution No. 1 Year 1970 will protect our workers or welders or even internship students who involve in the welding works with provision of personal protective equipment required for welders to perform their works which protect them from unsafe condition [7]. The companies which hire the welders shall obey the rule or regulation, they shall provide workers with the safe environment especially welders who deal with electrical or heat hazards and prone to any explosion or fire [8].

Indonesian Government with the Manpower Minister Degree also issued regulation number PER. 02/MEN/1992 (Year 1982) which administer the companies, schools, and institutions such as Professional Certification Bodies of how to qualify our welders [9]. The use of welder's qualification positions as per the below are prescribed in the regulation: 1) Grade 1 welder shall be qualified for positions of 1G, 2G, 3G, 4G, 5G and 6G. 2) Grade 2 welder shall be qualified for positions of 1G, 2G, 3G and 4G, and 3) Grade 3 welders shall be qualified for positions of 1G and 2G only.

The rule further specifies that Grade 1 welder is superior to other grades where they are qualified for Grade 2 and 3 as well, however, Grade 2 or 3 welders cannot be qualified to be Grade 1 welder [10]. Once the test coupons pass the tests then the welders shall be called as qualified welders. There is no expiry period of qualified welders in this regulation requirement, however, their qualification will be expired if they do not perform any welding work for the period of six months [11].

Other recent regulations issued by the Indonesian Government are Indonesian National Work Competence Standard or SKKNI (Standar Kompetensi Kerja Nasional Indonesia) issued by Manpower Minister numbers KEP. 342/MEN/X/2007 [10] and KEP. 105/MEN/V/2008 regarding how to qualify welders for SMAW and other processes. The competencies required for welders based on the Indonesian National Work Competencies above are as below [11]:

## 1.2 International Rules and Codes

For many years both American and European countries have developed rules and standards for welding such as ASME and AWS are the two American institutions or bodies

**Table 1.** Indonesian National Work Competencies for Welders (SMAW)

No.	Unit Code	Unit Competencies
<b>General Competencies</b>		
1	JIP. SM01.001.01	Performing mutual communication
2	JIP. SM01.002.01	Identification of Occupational Health and Safety Principles
3	JIP. SM01.003.01	Team works
4	JIP. SM01.004.01	Implement Occupational Health and Safety and Environmental works
5	JIP. SM01.005.01	Implement Quality System
6	JIP. SM01.006.01	Works planning
<b>Primary Competencies</b>		
7	JIP. SM02.001.01	Using basic mechanical measurement
8	JIP. SM02.002.01	Understand to read work drawings and sketches
9	JIP. SM02.003.01	Using hand tools and simple machines
10	JIP. SM02.004.01	Perform mechanical cutting
11	JIP. SM02.005.01	Perform gas cutting
12	JIP. SM02.006.01	Perform measurement using mechanical precision equipment
13	JIP. SM02.007.01	Able to read and understand technical drawings and welding symbols
14	JIP. SM02.008.01	Perform basic welding using manual arc welding
15	JIP. SM02.009.01	Weld plate with flat position manual arc welding (1G)
16	JIP. SM02.010.01	Weld plate with horizontal position manual arc welding (2G)
17	JIP. SM02.011.01	Weld plate with vertical position manual arc welding (3G)
18	JIP. SM02.012.01	Weld plate with overhead position manual arc welding (4G)
19	JIP. SM02.013.01	Weld pipe with horizontal axis rotated position manual arc welding (1GR)

(continued)

**Table 1.** (continued)

No.	Unit Code	Unit Competencies
20	JIP. SM02.014.01	Weld pipe with vertical axis rotated position manual arc welding (2GR)
21	JIP. SM02.015.01	Weld pipe with horizontal axis fixed position manual arc welding (5G)
22	JIP. SM02.016.01	Weld pipe with 45-degree fixed position manual arc welding (6G)
23	JIP. SM02.017.01	Weld plate and/or pipe with all positions using combination welding processes of TIG and SMAW
<b>Specific Competencies</b>		
24	JIP. SM03.001.01	Prepare or write reports
25	JIP. SM03.002.01	Perform basic technical calculations
26	JIP. SM03.003.01	Interpret English readings
27	JIP. SM03.004.01	Operate Computer
28	JIP. SM03.005.01	Implement Material handling
<b>Specific Competencies (Continued)</b>		
29	JIP. SM03.006.01	Understand materials use and characteristics
30	JIP. SM03.007.01	Perform maintenance on welding machines and equipment
31	JIP. SM03.008.01	Understand welding metallurgy

which developed the standards for welders' qualifications. ASME Section IX of Boiler and Pressure Vessels (2021) specifies that the qualification scheme for welders' qualification shall follow ASME IX Table QW-461.9 which details the qualified positions used during qualification welding i.e., 1G (Flat), 2G (Horizontal), 3G (Vertical), 4G (Overhead), 5G (Fixed Horizontal position) and 6G (Fixed 45-deg position) with the limitations of qualification as per Table 2 which referring to ASME IX Table QW-353 [4].

On the other hand, welding industries in Europe and most of Asian countries now more using ISO standards for their construction codes and for the qualification of the welders with using ISO 9606-1 [5]. From the Fig. 2, we can summarize that PA (Flat position), PB (Horizontal Vertical position), PC (Horizontal position), PD (Horizontal Overhead Position), PE (Overhead Position), PF (Vertical Position – Welding Upwards) and PG (Vertical Position – Welding Downwards) [12]. European standards are the emerging requirements, therefore, the researcher will focus on using European standards such as ISO 9606-1, ISO 6947 and IIW requirements for qualifying welders for the students of SMK [14].

### 1.3 CBET

Competency-based education and training provides the students with set of knowledge, skills, attitudes, and values which can be obtained and developed by the students where

they can deliver their daily assignments and when solving their daily problems [15]. Competent students especially in welding industry and the ability to gain the welding skills in accordance with both national and international competencies will guarantee the students of better employment from either national or international companies, especially those who operate in Batam and its neighbouring islands [16].

The competency-based education and training approach is aimed to expertise designed following teaching in the Vocational School curriculum which has implications for student [2]. Competency-based education and training will give results of skilled activities obtained by the students, it is their responsibility to perform the expected level of jobs complying with required criteria set by the industries, and it can be recognized nationally and as well as internationally [14]. Currently ASME based Indonesian National Work Competencies will be the national standards and European based qualification will now be introduced to the students to fill the current industry demands [15].

## 2 Method

Therefore, we need to develop the product based on the planning, develop preliminary product, field testing it, and evolves the products to meet their behaviour definitions and objectives [17]. There are ten steps which are developed by Borg and Gall, and they are comprising of 1) Need Analysis, 2) Planning, 3) Develop Preliminary Product, 4) Preliminary Field Testing, 5) Main Product Revision, 6) Main Field Testing, 7) Revision of Product, 8) Operational Field Testing, 9) Final Product Revision, and 10) Dissemination and Implementation [17]. Based on that methodology the research was developed with the model as per the Fig. 1.

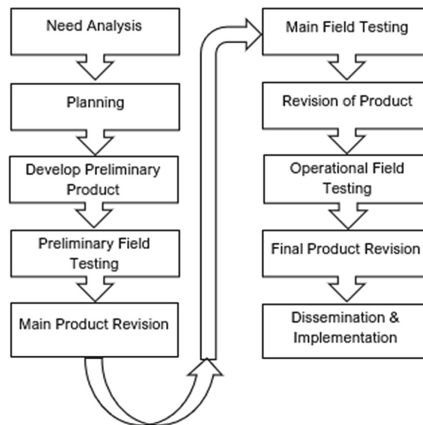


Fig. 1. Borg and Gall Steps Scheme

### 3 Results and Discussion

Each student is required to prove their knowledge and understanding to the assessment criteria and as well as welding body of knowledge set by either the school’s curriculum and Indonesian National Work Competencies competency level or international standards i.e. ISO 9606-1 and IIW welders scheme or Table 4 [18]. The difficulty which is faced by the students in deciding which education, training, or assessment standards to choose which competencies are needed in the field of welding and in order to determine the value of works because the existing assessments have not been able to reflect the student competencies [15]. The assessment model which the researchers designed is comprising of 6 levels, namely: (1) occupational safety (2) principles of welding, (3) drawing and weld symbol interpretation, (4) visual examination inspection, and (5) SMAW process knowledge, and (6) ISO 9606-1 acceptance criteria, which will refer to ISO 5817 Table 1 Quality Level B, and training criteria to follow IIW welder’s qualification scheme (See Fig. 2, Table 2 and 3) [19]. Therefore, the vocational school needs to

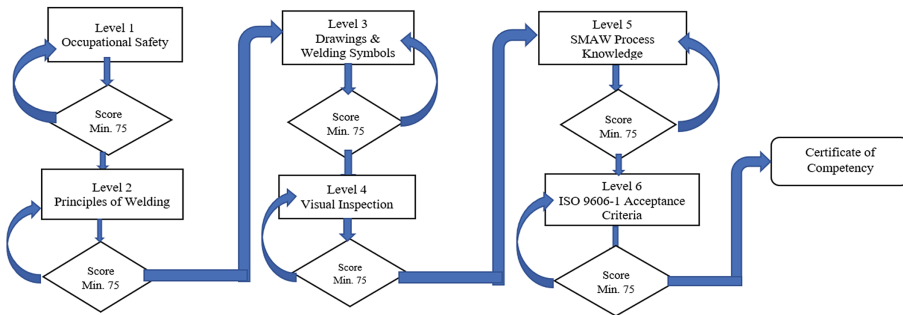


Fig. 2. CBET Rating Scheme (Explanation to the Scheme is described in Table 2)

Table 2. Schematic Level and Indicators (Explanation of the Scheme in Fig. 2)

Level	Indicators	
<b>LEVEL 1 - OCCUPATIONAL SAFETY</b>	1	Perform housekeeping duties daily
	2	Demonstrate proper use of PPE (Personal Protective Equipment)
	3	Demonstrate proper use of ventilation equipment
	4	Discuss proper Hot Works operation
	5	Discuss working inside confined space
	6	Discuss working at height

(continued)

**Table 2.** (continued)

Level	Indicators	
	7	Demonstrate knowledge of arc welding safety procedure & actions during emergency
<b>LEVEL 2 – PRINCIPLES OF WELDING</b>	1	Identify major types of metals (ferrous and non-ferrous) used in welding
	2	Select appropriate welding technique, equipment, and tools for the given metal and weld process
	3	Describe the industry accepted welding codes (SKKNI and ISO 9606-1)
	4	Describe the understanding of welding procedure (WPS) and welder's qualification
	5	Identify various join designs (geometry)
	6	Demonstrate cleaning and preparation of materials prior to cutting and welding
	7	Demonstrate proper use of hand tools (chisel, hammer, grinder, file, etc.)
	8	Demonstrate knowledge of preheat application
<b>LEVEL 3 – DRAWINGS AND WELDING SYMBOLS</b>	1	Interpret basic elements of a drawing or sketch
	2	Interpret welding symbol information
	3	Fabricate parts from a drawing or sketch
	4	Demonstrate use of measuring equipment
	5	Demonstrate knowledge of basic metric conversion
	6	Demonstrate understanding of weld maps
<b>LEVEL 4 – VISUAL INSPECTION</b>	1	Check the visual of cut or bevel edges of base material prior to welding
	2	Check cleanliness of interpass welds during welding
	3	Identify and evaluate surface defects against acceptance standards
	4	Demonstrate visual inspection and prepare simple reports

(continued)

**Table 2.** (continued)

Level	Indicators	
	5	Understand codes and standards related to weld acceptance criteria
	6	Understand Non-Destructive and Destructive test methods applied on welds
<b>LEVEL 5 – SMAW PROCESS KNOWLEDGE</b>	1	Check the condition of the SMAW machine
	2	Set up and operate the welding machine
	3	Perform fillet & groove welds in all positions
	4	Pass performance tests in all positions
	5	Trouble-shooting the SMAW machine

**Table 3.** Level 6 ISO 9606–1 Acceptance Criteria (Explanation of the Scheme in Fig. 2)

<b>LEVEL 6 – ACCEPTANCE CRITERIA (ISO 5817 Table 1 Quality Level B)</b>		
No	Description	Limit
1.1	Crack	Not permitted
1.2	Crater crack	Not permitted
1.3	Surface porosity	Not permitted
1.5	Lack of fusion (Incomplete fusion)	Not permitted
1.6	Incomplete root penetration	Not permitted
1.7	Continuous undercut	Not permitted
1.7	Intermittent undercut	As per the limit
1.9	Excess weld metal	As per the limit
1.10	Excess penetration	As per the limit
1.15	Burn through	Not permitted

develop new design which comply with SKKNI or American standards and at the same time comply with European or ISO standards (ISO 9606-1 and IIW scheme) [13].



**Table 4.** IIW Guideline for International Welder Assessment

<b>COMPETENCY LEVEL &amp; GRADING</b>		
<b>IIW Guideline for International Welder (IAB-089r5-14) for MMAW</b>		
<b>No</b>	<b>Description</b>	<b>Score Max.</b>
A	Module A	
A.1	Handling electricity for arc welding	0.4
A.2	Obtain Proper Knowledge on Welding Equipment	0.4
A.3	Understanding Basic Health and Safety	0.4
A.4	Demonstrate Safe Working in the Fabrication Shop	0.4
A.5	Obtain Knowledge of Welding Consumables	0.4
A.6-7	Perform Welding Practice	0.5
A.8	Introduction to Steel Materials	0.4
A.9	Qualification of Welders & Welding Operators	0.5
B	Module B	
B.1	Understand Methods of joint preparation for welding	0.4
B.2	Perform Welded joints in plates	0.4
B.3	Understand Weldability of Steels	0.4
B.4	Understand the Causes of Shrinkage, residual stress, distortion	0.4
B.5	Understand the Cause of Weld Imperfections	0.4
B.6	Understand Overview of fusion welding processes	0.4
B.7	Perform Safe working on site	0.4
B.8	Understand the use of Inspection and Testing	0.4
B.9	Understand the basis of Quality Assurance in welding	0.4
SA	Discussion on Supplementary for MMA welding	
SA.1	Understand Construction and maintenance of MMA welding equipment & typical welding parameters	0.5
SA.2	Understand how to use Covered Electrodes	0.5
SA.3	Demonstrate Health and Safety	0.4
P	Understand Specific Materials	
PSS	Understand and Demonstrate Welding of Stainless-Steel materials	0.8
PAL	Perform Welding on Aluminium materials	0.8
Total Value		10

## 4 Conclusion

This research reveals that the competency-based education and training (CBET) using Borg and Gall improvement method will give students more opportunity in obtaining opportunity to be hired as welders or welding operators in Batam, compared with just normal welder training scheme. This research will give contribution to Vocational Schools which develop the welding curriculum by integration to the new method of competency as described in this research. The limitation of this research is that currently there is no formal acknowledgement from official institutions which can spread the implementation to more extensive use. The researcher suggest that this study can be broaden and explored by other researchers to extend its basis of usage.

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