

**GENERATION, MANAGEMENT PRACTICES, AND USERS' AWARENESS ON  
WELDING WASTE AT VOCATIONAL COLLEGES**

**JIMMY CHONG**

**THESIS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT FOR THE  
MASTER OF SCIENCE (TECHNICAL AND VOCATIONAL EDUCATION)  
(MASTER BY RESEARCH)**

**FACULTY OF TECHNICAL AND VOCATIONAL EDUCATION  
UNIVERSITI PENDIDIKAN SULTAN IDRIS**

**2015**

## ABSTRACT

This study aims to investigate the generation rates and composition, management practices, and peoples' awareness on welding waste related issues. Descriptive survey design was adopted, and data were collected from six vocational colleges located in the central zone of peninsular Malaysia. Methods used for data collection include on-site waste measurement, survey questionnaires, semi-structured interviews, and field observation. Quantitative data were analyzed using Statistical Programme for Social Sciences (SPSS) while the qualitative data were analyzed by classifying data into emerging categories and themes. The results revealed that welding waste issues in vocational colleges were significant, based on amount, composition, management and peoples' awareness. On average, welding waste generation rates were up to  $83.42 \text{ kgw}^{-1}$  and per capita generation rate was  $1.23 \text{ kgw}^{-1}\text{st}^{-1}$ . Welding wastes were composed of scrap metal, metal dust, welding electrodes, and grinding disks. Scrap metal constituted up to 92.89 percent of the total welding waste. Management practices such as on-site storage, handling, waste collection and removal from the source were relatively similar among the workshops. The study also found that waste separation and metal dust handling were unsatisfactory. In term of awareness, high levels of teachers' and students' awareness were recorded. Linear regression analysis suggests that students' waste practices were significant to explain 68.1 percent variance in waste generation rates. The obtained data have illustrated that further improvement in various aspects of welding waste management in vocational colleges welding workshops is needed. Initial effort can be made through the establishment of standard to guide peoples' practices and further enhance their levels of awareness on waste management in the welding workshop.

## **PENJANAAN, AMALAN PENGURUSAN DAN KESEDARAN PENGGUNA TERHADAP SISA KIMPALAN DI KOLEJ VOKASIONAL**

### **ABSTRAK**

Kajian ini bertujuan untuk menilai beberapa aspek berkaitan sisa kimpalan di kolej vokasional termasuk kadar penjanaan dan komposisi sisa kimpalan, amalan pengurusan sisa kimpalan serta tahap kesedaran guru-guru dan pelajar berkaitan dengan sisa kimpalan. Reka bentuk kajian deskriptif telah digunakan dalam kajian ini. Data diperolehi daripada enam buah kolej vokasional di zon tengah Semenanjung Malaysia. Kaedah pengumpulan data yang digunakan termasuklah pengukuran sisa di lokasi kajian, soal selidik, temu bual separa berstruktur, dan pemerhatian di lokasi kajian. Data kuantitatif dianalisis menggunakan Program Statistik untuk Sains Sosial (SPSS) manakala data kualitatif telah dianalisis dengan mengklasifikasikan data ke dalam kategori dan tema yang muncul. Dapatan kajian menunjukkan bahawa isu sisa kimpalan di kolej vokasional adalah signifikan berdasarkan kepada jumlah sisa yang dijana, komposisi sisa, pengurusan sisa dan kesedaran dalam kalangan pengguna. Secara purata kadar penjanaan sisa kimpalan adalah sehingga  $83.42 \text{ kgw}^{-1}$  dan kadar penjanaan per kapita adalah  $1.23 \text{ kgw}^{-1}\text{st}^{-1}$ . Sisa kimpalan yang dihasilkan di bengkel kimpalan terdiri daripada logam terpakai, debu logam, elektrod kimpalan, dan roda pencairi. Logam terpakai menyumbang sehingga 92.89 peratus daripada jumlah sisa kimpalan. Dari segi pengurusan, kaedah penyimpanan, pengendalian, pengumpulan dan pelupusan sisa di semua bengkel kimpalan yang terlibat secara relatifnya tidak mempunyai perbezaan yang ketara. Dapatan kajian juga menunjukkan amalan pengasingan sisa dan pengendalian debu logam adalah tidak memuaskan. Namun, tahap kesedaran guru dan pelajar terhadap pengurusan sisa adalah tinggi. Analisis regresi linear menunjukkan bahawa amalan pelajar terhadap pengurusan sisa mempengaruhi secara signifikan ke atas kadar penjanaan sisa dengan nilai varian 68.1 peratus. Data yang diperolehi menunjukkan keperluan penambahbaikan dalam pelbagai aspek pengurusan sisa kimpalan di kolej vokasional. Usaha awal perlu dilakukan dengan menyediakan piawai yang boleh memperbaiki amalan pengurusan sisa dalam kalangan pengguna bengkel dan seterusnya meningkatkan tahap kesedaran mereka terhadap pengurusan sisa di bengkel kimpalan.

## TABLE OF CONTENTS

	<b>Page</b>
<b>DECLARATION</b>	ii
<b>ACKNOWLEDGEMENT</b>	iii
<b>ABSTRACT</b>	iv
<b>ABSTRAK</b>	v
<b>TABLE OF CONTENTS</b>	vi
<b>LIST OF TABLES</b>	xiii
<b>LIST OF FIGURES</b>	xv
<b>LIST OF ABBREVIATIONS</b>	xvii
<b>CHAPTER 1 INTRODUCTION</b>	
1.1 Introduction	1
1.1.1 Sustainability in educational institution	1
1.1.2 Transformation of vocational education	3
1.2 Background of the study	4
1.3 Problem statement	6
1.4 Research objectives	7
1.5 Research questions	8
1.6 Research conceptual framework	9
1.7 Significance of the study	11
1.8 Scopes and limitations of the study	12

## 1.9 Operational definitions

13

**CHAPTER 2 LITERATURE REVIEW**

2.1	Introduction	16
2.2	Human and environment	16
2.3	Solid waste issues	17
2.4	Solid waste generation at global and national scales	20
2.5	Solid waste composition	23
2.6	Solid waste management in Malaysia	24
2.7	Components in solid waste management	25
2.7.1	Waste generation	26
2.7.2	Waste storage at the source	27
2.7.3	Waste collection	27
2.7.4	Waste transfer and transportation	29
2.7.5	Final disposal	30
2.8	Waste minimization	30
2.9	Need for waste management in educational institution	32
2.10	Vocational education institution	33
2.11	Teaching and learning activities in welding technology course	37
2.12	Solid waste generated in vocational colleges welding workshops	38



3.5.2 Qualitative data analysis from interview and  
observation

62

## CHAPTER 4 RESULT AND DATA ANALYSIS

4.1	Introduction	63
4.2	Respondents demographic information	64
4.2.1	Teachers demographic description	64
4.2.2	Students demographic description	65
4.3	Welding waste generation and composition	68
4.4	Assessment of the current waste management practices in vocational colleges welding workshops	74
4.4.1	On-site waste storage	74
4.4.2	On-site waste handling	77
4.4.3	On-site waste collection and removal	82
4.4.4	Recycling and minimization	83
4.4.4.1	Relationship between welding waste generation and raw material usage	83
4.4.4.2	Measures taken to minimize waste generation	87
4.4.4.3	Limiting raw material and consumable usages	88
4.4.4.4	Reuse of scrap metal for early welding practice	90
4.4.4.5	Reuse electrodes	92

UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDID
N IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI F
	4.4.4.6 Segregation of recyclable waste materials	95
	4.4.5 Qualitative data obtained through interview and field observation	96
	4.4.5.1 Interview	96
	4.4.5.2 Field observation	102
4.5	Teachers' and students' awareness on waste generation issues, the importance of proper waste management and waste minimization	105
4.5.1	Awareness on waste generation issues among teachers and students	105
4.5.2	Awareness on a proper waste handling and management among teachers and students	109
4.5.3	Awareness on the importance of waste minimization	113
4.6	Linear regression analysis of waste generation, peoples' awareness on waste related issues and waste minimization practices	118

**CHAPTER 5 DISCUSSION**

5.1	Introduction	121
5.2	Discussion of the study findings	122
5.2.1	Welding waste generation and composition	122

5.2.2	Assessment of the current waste management practices in vocational colleges welding workshops	126
5.2.2.1	On-site waste storage	127
5.2.2.2	On-site waste handling	128
5.2.2.3	On-site waste collection and removal	131
5.2.2.4	Measures taken to minimize waste generation	134
5.2.3	Teachers' and students' awareness on waste generation issues, the importance of proper waste management and waste minimization.	137
5.2.3.1	Awareness on waste generation issues among teachers and students	138
5.2.3.2	Awareness on a proper waste handling and management among teachers and students	139
5.2.3.3	Awareness on the importance of waste minimization	140
5.2.4	Relationship between waste generation, peoples' awareness on waste related issues and waste minimization practices	142
5.3	Conclusions	143
5.4	Recommendations for welding waste handling guideline in vocational college	149

UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS
UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS
5.4.1	Welding workshop		150
5.4.2	Waste storage		151
5.4.3	Waste handling		152
5.4.4	Waste collection and removal		153
5.4.5	Waste minimization		154
5.5	Study contributions		156
5.6	Recommendations for future research		157
<b>REFERENCES</b>			159
<b>APPENDICES</b>			169



## LIST OF TABLES

<b>No. of Table</b>		<b>Page</b>
2.1	Sources, typical generators and types of municipal solid waste	18
2.2	Current waste generation and projection for 2025 by region	20
2.3	Solid waste generation rates in urban areas in Peninsular Malaysia by from 1996 to 2007 ('000 tonnes)	22
2.4	The compositions of solid wastes (percentage of wet weight) in Malaysia from 1975 to 2006	23
2.5	List of study areas and courses offered in vocational college	34
2.6	The main features of the vocational college curriculum	36
3.1	Numbers of welding students and teachers in selected vocational college	49
3.2	Questionnaires return rate	55
3.3	Cronbach's alpha coefficient ( $\alpha$ ) for teachers' and students' questionnaires	59
4.1	Teachers demographic information	66
4.2	Students demographic information	67
4.3	The average weekly total waste generation rates ( $\text{kgw}^{-1}$ ) in six vocational college welding workshops	68
4.4	Constituent percentages of welding waste in six vocational colleges	71
4.5	Weekly generation rates ( $\text{kgw}^{-1}$ ) of each welding waste component in six vocational college welding workshop	72
4.6	Per capita generation rates ( $\text{kgw}^{-1}\text{st}^{-1}$ ) of each welding waste components in six vocational college welding workshops	73
4.7	Storage bins for wastes in welding workshop	76

UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS
N IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS	UNIVERSITI PENDIDIKAN SULTAN IDRIS
4.8	On-site welding waste removal method and frequency in the six welding workshops	82
4.9	The average number of weekly welding project completed by students	84
4.10	Respondents' reply on interview question 1	97
4.11	Respondents' reply on interview question 2	98
4.12	Respondents' reply on interview question 3	99
4.13	Respondents' reply on interview question 4	100
4.14	Respondents' reply on interview question 5	101
4.15	Field observation data	104
4.16	Teachers and students' awareness on waste generation issues	107
4.17	Teachers and students' awareness on a proper welding waste management	111
4.18	Teachers and students' awareness on the importance of waste minimization	115
4.19	Linear regression analysis of waste generation, peoples' awareness on waste related issues and waste minimization practices	119

## LIST OF FIGURES

<b>No. of Figure</b>		<b>Page</b>
1.1	Research conceptual framework	10
2.1	Malaysia per capita generation of solid waste from 1985 to 2010	21
2.2	Components and flow of solid waste management process	26
2.3	Waste management hierarchy	31
2.4	Major types of metal welding and metal cutting process used in vocational college welding workshops	38
2.5	Example of solid wastes being generated through teaching and learning in vocational college welding workshops	39
3.1	Research process	46
3.2	On-site measurement of welding waste by the researcher	52
4.1	Boxplots of weekly waste generation rates over the whole study period in all vocational colleges	69
4.2	Composition of welding waste in welding workshop	70
4.3	Example of containers used to store scrape metal and electrodes	76
4.4	The percentages of teachers and students who were practice waste segregation	78
4.5	The percentages of teachers and students who store consumables and metal waste together	79
4.6	Metal dust being store together with metal waste	80
4.7	Handling of metal dust among teachers and students	81
4.8	Relationship between the average weekly waste generations with the number of weekly welding project per student	85
4.9	Multiple welding attempts among students in the studied vocational college welding workshop	86

4.10	Main reasons associated with single project multiple welding attempts by students in the studied vocational colleges	87
4.11	The percentages of teachers who limit raw material and consumables usage	89
4.12	The percentages of teachers who keep track on the amount of raw materials used by students	89
4.13	Action taken by students when they make mistake during welding process	90
4.14	The percentages of teachers who instruct students to practice with scrap metal	91
4.15	The percentages of students who do early welding practice with scrap metal	92
4.16	Percentages of teachers who instruct student to reuse electrodes	93
4.17	Percentages of students who reuse electrode	94
4.18	Students' preference of electrode length for reuse	94
4.19	Percentages of teachers who instruct student to segregate waste for recycling	95
4.20	Percentages of students who segregate waste for recycling	96
4.21	Mean score of teachers and students' awareness on waste generation issues	109
4.22	Mean score of teachers and students' awareness on a proper welding waste management	113
4.23	Mean score of teachers and students' awareness on the importance of waste minimization	117
5.1	Metal dust accumulate in drain	131

## LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
EAP	East Asia and Pacific
EC	European Commission
EMS	Environmental Management System
EPA	The Environmental Protection Agency
ESAB	Elektriska Svetsnings-Aktiebolaget
ISO	International Organization for Standardization
ISO 14001	ISO 14001 Environmental Management System-Specification with Guidance for Use
KPM	Kementerian Pendidikan Malaysia
LCA	Life Cycle Assessment
MSW	Municipal Solid Waste
OECD	Organization for Economic Co-operation and Development
PPSPPA	Perbadanan Pengurusan Sisa Pepejal dan Pembersihan Awam
SPSS	Statistical Package for Social Science
UN	United Nations
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNESCO	United Nations Educational, Scientific and Cultural Organization
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
WHO	World Health Organization

## LIST OF APPENDICES

- A Approval letter from the Education Planning and Research Department (EPRD)
- B Approval letter from the Department of Technical and Vocational Education (BPTV)
- C Experts' appointment letter
- D Instruments validity form
- E Teachers' questionnaire
- F Students' questionnaire
- G Workshop leader interview questions
- H Observation sheet
- I Waste quantification sheet



## CHAPTER 1

### INTRODUCTION

#### 1.1 Introduction

This chapter mainly provides the outlook of the research area, problems and significance which justify the relevance of this study. Furthermore, this chapter also elaborates the connection of each component investigated in this study.

##### 1.1.1 Sustainability in educational institution

Sustainability is targeting at protecting the environment for future generation through best environmental practices to ensure the efficiency of resource usage and minimal pollution (Barrow, 2006). To date, many environmental best practices (green practices)

UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS

UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS

have been assembled in various areas, including in educational institutions for broad applicability and benefit towards the environment (Hens et al., 2010).

Educational institution is considered as an essential body for achieving sustainability (UNESCO, 2006). This is due to the fact that the quality of the environment depends critically on the level of knowledge, attitude, values and practices of the future leaders and citizens (Schultz & Oskamp, 1996; Kuhlemeier et al., 1999). Therefore, educational institution should have a healthy environment, prosperous economy through energy and resource conservation, waste reduction and an efficient environmental management. This will provide the basis to export the values associated with sustainable practices to the community, at national and global levels.

Education for sustainable development (ESD) is the key element in developing environmentally literate citizens. ESD is also known as education in the new millennium, in which it emphasizes on education for social transformation with the goal of creating more sustainable societies (UNESCO, 2012). ESD provides an integrated approach to develop the knowledge, skills, values, behavior, and lifestyles which will empower everyone to make appropriate decisions related to any emerging environmental issues.

ESD has been designed to emphasize on four major aspects which include (1) improving access to quality basic education, (2) re-orientating the existing education to address sustainability, (3) increasing public awareness on sustainability, and (4) providing professional training infused with the practices and principles of

sustainability (UNESCO, 2012). In general, these aspects can be achieved through formal and informal education.

### **1.1.2 Transformation of vocational education**

Education is a multi-million ringgits industry and it is vital for the development of a nation and determine the future of engineering education, especially when the country aims to achieve the status of industrial based developed country as stated in the 2020 Vision. According to Nurazimah and Yusri (2013) , educational institutions play an important role towards achieving national educational goals of developing a world-class education system. A good and high quality of work ethic should be adopted to ensure that all educators feature excellent qualities, responsibility and a high level of professionalism in carrying out the duties and responsibilities.

The education system in Malaysia has gone through various reforms since the days of independence. These changes were done through an effort of the Ministry of Education (MOE) to improve the existing education system. The reforms are in line with the current requirements to improve the quality and productivity in Malaysia, and to make Malaysia as a center of educational excellence and providing world-class education in this country (Yusoff et al., 1999).

The aspirations of the Government Transformation Programme and the New Economic Model, which is based on the high-income economy is to produce innovative human capital with the ability to explore new areas and generate country wealth. This

high national economic growth has been demanding an increase in the number of graduates in technical and vocational fields. The government through the 2013 budget has allocated substantial funds to improve the quality of education in Malaysia, especially in fulfilling the National Education Development Plan (2013-2025). Therefore, vocational education in Malaysia has undergone a major change since the launch of Vocational Education Transformation on January 6, 2012. The new definition of success through vocational education can be seen through the operation of 15 upgraded vocational schools to the Vocational Colleges in 2012 with the enrollment of 3120 students. In 2013, another 72 vocational school were upgraded to Vocational Colleges with a total of 21,250 students' enrollment.

Vocational education transformation that began in 2011 has emphasized an industrial practices and internship program that will reduce the academic composition. The new curriculum are based on the National Occupational Skills Standards (NOSS) and other forms of certification that is recognized by the industry. Vocational education and training certainly have an important role in providing the main route towards producing highly skilled human capital, thus contributing to the generation of new wealth for the country. The new vocational colleges' curriculum consists of 53 types of courses in 12 fields of specialization.

## **1.2 Background of the study**

The environmental quality and its health state are continuously deteriorated mainly due to increase in human activities. Human activities which contribute to environmental

UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS

UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS      UNIVERSITI PENDIDIKAN SULTAN IDRIS

degradation may range from small scale home activities to large scale industrial and mining activities (Goudie, 2006). Due to this, many countries around the world is targeting at reducing the human impacts on the environment through sustainable practices in most activities (UNEP, 2007).

Educational institutions have been recognized to have the same standard as industries with regards to its impact on environment (Savely et al., 2007). Human activities resulting from educational institutions may give more pressure on the environment partly due to high solid waste generation rates (USEPA, 2008). Additionally, solid wastes generated from educational institutions are also composed of hazardous and scheduled waste (USEPA, 2008).

In Malaysia, the largest number of educational institution is school, which made up of primary, secondary and vocational schools. In 2012, vocational schools were transformed into vocational colleges. In total, 10,019 of primary, secondary and vocational institution are currently operating with approximately 5.3 million students enrolled and 0.4 million teachers employed (Kementerian Pelajaran Malaysia, 2012). As a result, approximately 20 percent of Malaysia population is directly involved with activities in these institutions. These numbers depict the significant amount of solid wastes being generated there. It has been suggested that educational institution could generate up to 30 percent of the total national wastes (Baca, 2011). Furthermore, many studies and reports have shown that educational institutions' waste materials, particularly from science laboratory or workshop, are considered as hazardous with health risks potential (USEPA, 2006). Even so, a recent study had suggested that proper solid waste management system is lacking in educational institutions and contributing

to various environmental issues especially pollutions (Ana et al., 2011). Therefore, solid waste is an important issue to be addressed in educational institutions to ensure minimal environmental impacts due to waste being produced.

### 1.3 Problem statement

Teaching and learning in vocational schools (currently known as vocational colleges) is associated with more activities in workshop and laboratory, in comparison to other types of school. In vocational colleges, 70 percent of student's learning time are workshop (Kementerian Pelajaran Malaysia, 2011). Hence, vocational colleges may generate more solid wastes through teaching and learning activities. Additionally, it has been suggested that activities being carried out in vocational workshops will produce by-products that may have impact to the environment (Darmiatun, 2008).

There are many teaching workshop in vocational colleges and each is producing unique type of solid wastes. For example, vocational colleges welding workshops produce many types of waste and by-products which include metal scrap, welding slags, dusts, powders and mists that may contain various hazardous metal oxides (Geraghty et al., 2011). The potential environmental impacts of welding wastes are significant as welding technology course is being offered in up to 55 percent (Kementerian Pelajaran Malaysia, 2015) of government-owned vocational colleges nationwide.

Despite of the large potential of environmental impacts due to activities in vocational colleges, this issue has received minimal attention from researcher and the

authorities. In fact, educational planners are more interested in issues such as the number of schools, teachers, and students' infrastructural facilities like classrooms and school buildings in improving educational institution (Egim, 2003 as cited in Obong et al., 2010). As a result, it is common to see poorly maintained school environment, thus effecting environmental quality and students' learning and intellectual development (Obong et al., 2010). To the writer's knowledge (through literature research), the present state of environmental practices, particularly on solid waste management in Malaysia vocational colleges workshops, remain insufficiently explored. To address this gap, this study has focused on waste generation and composition, current waste management practices, and teachers' and students' awareness in vocational colleges welding workshop. The findings of this study are essential to trigger necessary actions towards achieving sustainable waste management practices in vocational educational institutions.

#### **1.4 Research objectives**

In relation to the discussed issue, vocational colleges welding workshops will be studied as a proxy to understand the pattern in waste generation and composition, current waste management practices, and teachers and students level of awareness on waste related issue in vocational colleges. This is mainly due to the significance of welding workshop in relation to high waste generation. In more specific, the specific objectives are as follow:

- i. To identify the generation rates and composition of waste in vocational colleges welding workshops;
- ii. To determine the current waste management practices in vocational colleges welding workshops;
- iii. To assess the levels of teachers' and students' awareness on waste generation issues, the importance of proper waste management and waste minimization in vocational colleges welding workshop;

### **1.5 Research questions**

In order to meet the stated objectives, this study will seek answers to the following research questions:

- i. What are the waste generation rates and composition in vocational colleges welding workshops?
- ii. What are the current waste management practices in vocational colleges welding workshops?
- iii. What are the teachers' and students' levels of awareness on waste generation issues, the importance of proper waste management and waste minimization in vocational colleges welding workshops?