Jilid 8/ Volume 8
Julai 2019/ July 2019

ISSN 1985-6652

JURNAL PERSATUAN PENDIDIKAN TEKNIK DAN VOKASIONAL MALAYSIA

TECHNICAL AND VOCATIONAL EDUCATION MALAYSIA JOURNAL

Persatuan Pendidikan Teknik dan Vokasional Malaysia

IPC-A-610 STANDARD IN ELECTRIC AND ELECTRONIC LABORATORY FOR ENGINEERING STUDENTS: A SYSTEMATIC LITERATURE REVIEW

Murugan Subramaniam[a]
Muhammad Khair Noordin[b]
Aini Najwa Azmi[c]

[a,b,c] Faculty of Education, Universiti Teknologi Malaysia, 81310 UTM, Skudai, Johor Darul Takzim, Malaysia
murugan2@graduate.utm.my

ABSTRACT

Printed circuit board (PCB) creates platform for the majority of the electronic component placement. Component connectivity has been converted from manual soldering to surface mount technology (SMT) or well known as a solder paste technology. Even though SMT has conquered the electronics era in recent decades; manual soldering still plays a significant part behind the scene. Introduction of instruments such as Six Sigma and Total Quality Management emphasis on minimizing the frequency of occurrence of defects. Since defects cannot be eliminated but can be reduced; the method called rework and troubleshooting carries weight to repair the faulty components turn into good components. In this context, it is most welcome to repair the defective Printed Circuit Board Assembly (PCBA) by using "manual soldering" because manual soldering can be carried out immediately without queuing in the soldering oven (James et al., 2019). The goal of this study is to construct standard understanding of International Patent Classification (IPC) among Malaysian engineering students during their practical activity in engineering laboratory. Currently, end consumers prefer to repair the electronics gadget instead of buying the fresh units. In addition, purchasing repaired device becomes popular among clients who prefer to own more than one device such as mobile phone, laptop, tablet and other electronic gadgets. Therefore, IPC expertise will assist the repairer make a choice on the repaired units without relying on In-Circuit-Test (ICT) and Functionality-Circuit-Test(FCT).

Keywords: *IPC; Failure; Soldering; Inspection; Quality; Troubleshooting; Surface Mount Technology*

1. INTRODUCTION

The soldering quality and efficiency differ based on tip geometry, board thickness, temperature, flux type, method and abilities. Every day, soldering knowledge is just not enough. Therefore, the technical note defines some basic thumb rules to be applied to all required manual soldering operations. With the appropriate reference standard, productivity will enhance, the right instruments and methods, board quality and rework consistency and board harm will be held to a minimum (Sloan and Huerta, 2017). Knowledge of the IPC-A-610 standard plays an important part among engineers in making the right choice to accept the reworked PCB based on criteria set (IPC-A-610D, 2004).

2. LITERATURE REVIEW

Automated optical inspection (aoi) is commonly used in the electronic manufacturing sectors to fix solder joint and connectivity issues in the printed circuit board (pcb). An automatic optical inspection (aoi) algorithm was created to check solder joint flaws of integrated circuit (ic) parts on printed circuit boards (pcbs). The findings of the inspection indicate that ic solder joint failures such as excess solder, lack of solder, no solder, lead lift, lead bend, shift, and bridged and pseudo joints can be efficiently recognized (wu and zhang, 2011).

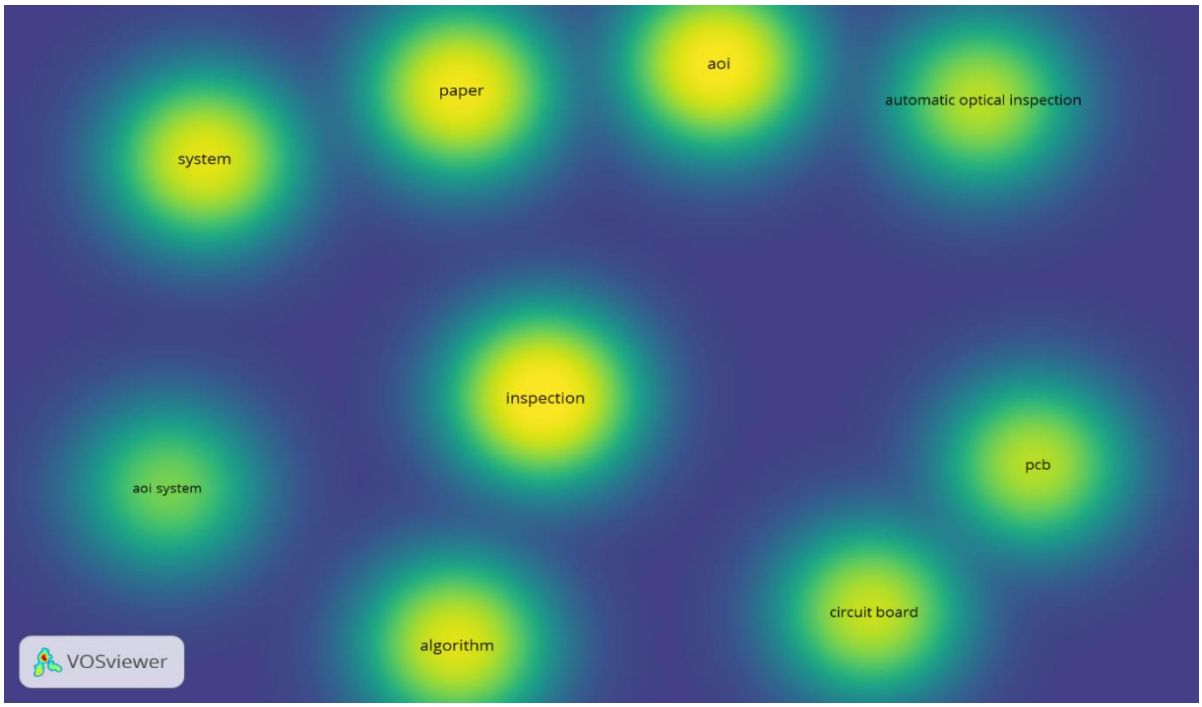

Figure 1: Automated Optical Inspection (AOI) and Manual Inspection according to IPC-A-610

Figure 1 demonstrates the word AOI system, paper, algorithm and printed circuit board heavily connected to each other. But the term "inspection" or known as "manual inspection" has the highest density. Manual inspection always refers to decision-making abilities according to the criteria set out in IPC-A-610. In this context, knowledge of IPC-A-610 provides adequate guidance to make the right choice to accept or reject PCBs with solder joint problems.

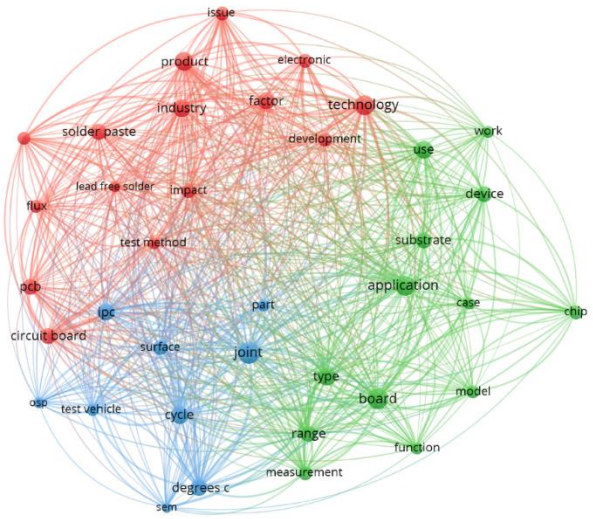

Figure 2: Solder and Manual Inspection according to IPC-A-610

The bibliometric network of Figure 2 indicates that there are three clusters. Each cluster evaluated with a minimum of 10 term occurrences. After that, evaluated again with a minimum of 5 term occurrences. The bibliometric network demonstrates that IPC-A-610 Standard has been strongly discussed with PCB, Industries, Solder Joint, test method and application. While reducing the occurrence period from 10 to 5, the network does not directly link the term IPC to the term university, student or engineering student. This is because the primary focus of universities is on theoretical understanding and simulation of software. As well as less concentrate on practical skills.

3. METHODOLOGY/MATERIALS

A systematic literature review starts with VOSviewer software version 1.6.11. The software promotes simulating ris, csv, and txt format from Web-of-Science (WoS) and converting bibliometric maps, network visualization, overlay visualization, and density visualization into required form (Eck and Waltman, 2016). Initial information collection has been extracted from WoS and has the earliest citation database; it has strong coverage with citation information and bibliographic data dating back to 1900 (Mascarenhas et al., 2018). Keywords; IPC; soldering; inspection; quality; troubleshooting; surface mount technology used to analyze the hypothesis. As of June 23, 2019, the information was collected and narrowed down to the engineering sector alone. In total, 181 WoS papers were selected for systematic literature review. Table 2, demonstrates the protocol for the systematic review of literature.

Table 2: Systematic Literature Review Protocol

Description	Conditions / Results
Objective	To perform a systematic literature review of theoretical and practical understanding of the soldering process in accordance with IPC-A-610 Standard. To evaluate current studies on problem solving abilities among graduate engineers in the region of hand soldering and surface mount technology. To determine the gap and the direction of future studies.
Source of Data	Web-Of-Science (WoS)

Area of Interest	Problem solving Skills Among Graduate Engineers at workplace / Manufacturing environment
Search field	Workplace competence; Problem Solving Skills; Manufacturing; Engineering; Soldering; IPC-A-610 and Surface Mount Technology
Covered Period	23/June/2019
Preliminary Document Selected	181- Web Of Science
Engineering Related Papers screened	44–WoS
Documents Analysis	Information based on content analysed with the aid of VOSviewer

4. RESULTS AND FINDINGS

Figure 3's bibliometric network shows that there are three clusters. Inspection, failure, and impact words have the greatest occurrences in their own clusters. At the same moment, these three keywords have a very strong connection between each other.

First cluster is made up of 43 items. In this cluster, the word "impact" has the largest incidence. Since the words "impact, temperature and strength" are tightly situated with "impact "; it proves that temperature and solder strength have had an impact on the functionality of the PCBs. In this cluster, the word "students" has less numbers and is far from the word "effect and change". Here it can be concluded that students still have little exposure about the cause and effect of PCB failures.

In the second cluster, the word "failures" is extremely linked to the terms "measurement and detection". In the manufacturing process of PCBs, failure detection is very important to avoid reaching customers with defective PCBs which incur high costs and waste. Therefore, adequate measurement and inspection is needed to identify the failure at an early point. Analysis shows that the word "students" from the first cluster is not immediately linked to the word "failure". It demonstrates that students are completely unaware of the sort of failure happening at the workplace.

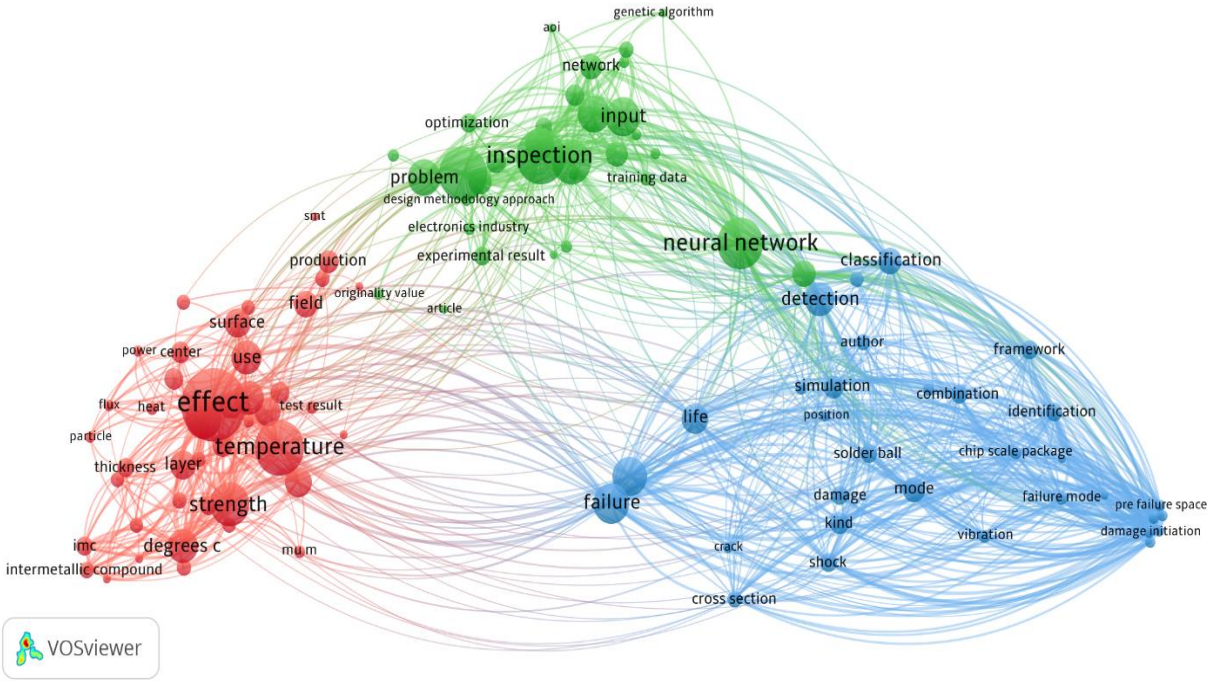

Figure 3: The analysis of abstract and title; 181 WoS documents (Keywords: Training and Solder)

The third cluster comprises of 32 items with a minimum of 5 occurrences. This cluster primarily describes the technique of inspection. Where the inspection technique is strongly linked to the word "operator." The inspection is carried out in industrial environment by operators and the engineers have to train them to inspect the solder condition of the PCBs according to standard operation procedure (SOP). The SOP will be created based on the IPC-A-610 standard by the engineers. The third cluster obviously explains that engineers acquire understanding of solder joint from electronics sectors and not from universities.

The bibliometric network demonstrates that there is zero link between terms IPC, Solder, Inspection and Students. But there are 6 papers accessible in Web-Of-Science that show connectivity between the terms student, training, solder, and inspection. The overview of six papers is shown in Table 2.

As mentioned in (Chandran et al., 2010), the University Research Team has been involved with 3 leading university equipment and has so far granted RM 4.9 million in study grants concentrating on multiple fields including nanotechnology, novel solder material, material surface modification and fresh methodology in solder joint assessment. This declaration explains that, before entering the industrial world, engineering learners must have basic understanding of solder joints which is transforming very rapidly. According to (Lakshmi Munukutla, Albert McHenry, Robert Darveaux, 2005) understanding of solder kinds such as lead-free is similarly essential in increasing green technology. Not only should future graduates have strong theoretical knowledge and professional abilities, but they also need to have a profound understanding of the production and management of electronic manufacturing companies. In addition, practical skills such as manual soldering operation, product assembly operation, product labeling code operation and product inspection operation should be mastered in a associated situation so that each graduate can adapt to work requirements as quickly as possible (Tian and Yang, 2018). Based on (James et al., 2019) bi-manual haptic training simulation interface for soldering SMD parts that speed up the skill learning curve and highly suggested for vocational schools and universities. Nevertheless, as noted by (Youtang et al.,

2009), to improve student capacity, new courses and new skills must be added to engineering classes. As suggested by (Manjabacas et al., 2009), soldering practice in the University Education System is very essential. It is necessary to take into account the concept of the multidisciplinary instructional system and involve an appropriate quantity of engineering content. This requires the undergraduates to attain a particular professional training. The fundamentals of the method and the mechanical conduct of the solder joints must be adequately evaluated.

The six articles as in table 2 obviously demonstrate the significance of solder joint assessment, soldering abilities, soldering tool choice, soldering wire kinds and solder joint acceptance standard. Fundamental data on solder joints obviously described with a correct pictorial diagram in IPC-A-610. Therefore, knowledge about IPC-A-610 is really essential among engineering students to make the correct solder joint choice.

5. CONCLUSION

Decision making and problem solving skills among graduate engineers are one of the most significant skills employers are looking for. Employers always prefer to enter their organization with "work prepared" engineer. PCB failures due to solder joint are common defects in the electronic industries and have a high impact on productivity. Knowledge of solder joint and solder paste is really essential in this context. Since undergraduate engineering students have practical classes in their engineering laboratory; awareness about IPC-A-610 must be introduced. As a course material, teachers and academic advisers should prepare good and defective samples to teach the student to inspect and make their choice either acceptable or not according to IPC-A-610 standard.

To conclude, academic teachers and universities must conduct a systematic evaluation to evaluate the student's knowledge and understanding of PCB and soldering situation and appropriate criteria in accordance with the IPC-A-610 standard. As mentioned in Figure 4, such a correct evaluation will generate "job prepared" engineers and will boost the employability rate among graduate engineers.

Table 3: The summary of 6 publications related to Students and Solder joint

Article	Author/ year	Journal	Total Citations	Methodology	Source
Success story of collaboration between Intel and Malaysian universities to establish and enhance teaching and research in electronic packaging	Chandran, Dennis Prem Kumar Sow, Yeek Kooi Harizan, Mohd Hasri Mohd Kooi, Chee Choong Hoy, Teoh Teik Foong, Chong Kim/2010	Proceedings of the IEEE/CPMT International Electronics Manufacturing Technology (IEMT) Symposium	0	Quantitative	Web Of Science
Graduate Education with Industry Relevance	Munukutla,Lakshmi; McHenry,Albert; Darveaux,Robert;/2005	Engineering Technology	0	Quantitative	Web of Science
The Practice and Exploration of Working and Learning Alternation Course Majoring in Applied Electronic Technology	Tian, Yi Yang, Xiao-ping/2018	Computer Science Proceeding paper	0	Quantitative	Web Of Science

of Advanced Vocational College					
Design of a bi-manual haptic interface for skill acquisition in surface mount device soldering	James, Jose Rao R, Bhavani Neamtu, Gabriel/2019	Soldering and Surface Mount Technology	0	Quantitative	Web of Science
Research and Practice for Innovation Capability Electrical and Electric Information Specialties	Youtang, G A O Yuan, X U Xiao, X U E Dayong, Huang/2009	Technology and Application of Electronic Information Research	0	Quantitative	Web of Science
An Educational Proposal: A Soldering Practice For Mechanical Engineering Students	Manjabacas, M. C. Martínez, A. Miguel, V. Coello, J. Calatayud, A./2009	AIP Conference Proceedings	0	Quantitative	Web Of Science

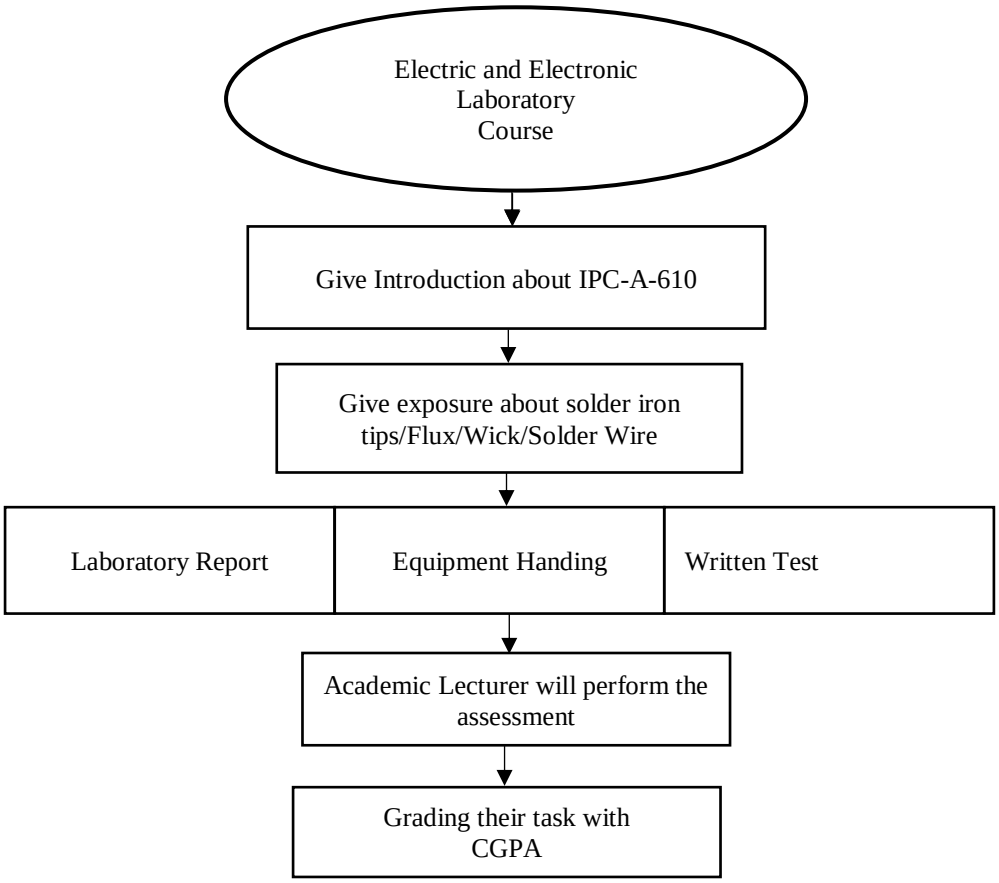

Figure 4: IPC-A-610 Standard in Electric and Electronics Engineering Laboratory Course

REFERENCES

Chandran, D.P.K., Sow, Y.K., Harizan, M.H.M., Kooi, C.C., Hoy, T.T., Foong, C.K., 2010. Success story of collaboration between Intel and Malaysian universities to establish and enhance teaching and research in electronic packaging. Proc. IEEE/CPMT Int. Electron. Manuf. Technol. Symp. https://doi.org/10.1109/IEMT.2010.5746684

Eck, N.J. Van, Waltman, L., 2016. VOSviewer Manual. Manual 1–28. https://doi.org/10.3402/jac.v8.30072

IPC-A-610D, 2004. Acceptability of Electronic Assemblies. Ipc 392.

James, J., Rao R, B., Neamtu, G., 2019. Design of a bi-manual haptic interface for skill acquisition in surface mount device soldering. Solder. Surf. Mt. Technol. 31, 133–142. https://doi.org/10.1108/SSMT-01-2018-0001

Lakshmi Munukutla, Albert McHenry, Robert Darveaux, G.T., 2005. Graduate Education with Industry Relevance.pdf.

Manjabacas, M.C., Martínez, A., Miguel, V., Coello, J., Calatayud, A., 2009. An educational proposal: A soldering practice for mechanical engineering students. AIP Conf. Proc. 1181, 704–714. https://doi.org/10.1063/1.3273691

Mascarenhas, C., Ferreira, J.J., Marques, C., 2018. University-industry cooperation: A systematic literature review and research agenda. Sci. Public Policy 45, 708–718. https://doi.org/10.1093/SCIPOL/SCY003

Sloan, D., Huerta, L., 2017. Hand Soldering Basics 1 1–6.

Tian, Y., Yang, X., 2018. The Practice and Exploration of Working and Learning Alternation Course Majoring in Applied Electronic Technology of Advanced Vocational College. https://doi.org/10.1145/3157737.3157751

Wu, F., Zhang, X., 2011. Feature-extraction-based inspection algorithm for IC solder joints. IEEE Trans. Components, Packag. Manuf. Technol. 1, 689–694. https://doi.org/10.1109/TCPMT.2011.2118208

Youtang, G.A.O., Yuan, X.U., Xiao, X.U.E., Dayong, H., 2009. Research and Practice for Innovation Capability Electrical and Electric Information Specialties 17–21.