INTERNATIONAL JOURNAL OF ACADEMIC RESEARCH IN PROGRESSIVE EDUCATION & DEVELOPMENT

OPEN ACCESS JOURNAL

Vol 10, Issue 4, (2021) E-ISSN: 2226-6348

The Factors that Influenced the Selection of Embedded Microcontroller for Teaching Embedded System Design and Interfacing Course

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To Link this Article: http://dx.doi.org/10.6007/IJARPED/v10-i4/11313 DOI:10.6007/IJARPED/v10-i4/11313

Published Online: 18 November 2021

Abstract

This article reports the factors that influenced the selection of embedded microcontrollers for teaching the embedded system and interfacing course at the School of Electrical Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia. The article analyses the data for 10 years from the beginning of the course offered in 2010 until 2019 for capturing the important criteria and pattern in the selection microcontroller for teaching embedded system courses. The data was captured from all documents related to the courses, including the course outline, course information, student report, Continuous Quality Improvement (CQI) report, Industrial Advisory Panel (IAP) report, and accreditation report. These documents were thoroughly examined and analysed to identify the reason for selecting the type of embedded system microcontrollers used for teaching and learning in the course from the early day offering until 2019. The finding shows that the cost is the main factor followed by robust and facilities that influence the selection of the embedded microcontroller in the course. In conclusion, the selection criteria are extremely important in selecting and justifying the suitable embedded microcontroller for the embedded system design and interfacing course, evidenced by the trend finding in this study.

Keywords: Microcontroller, Selection Factors, Embedded System Course

Introduction

The demand for the embedded system course in electrical and electronics engineering and technology programs globally increases dramatically in the Internet of Things (IoT) era (Karunaratne, 2019; Karvinen & Karvinen, 2018; Malaoui, 2016; Martelaro et al., 2020; Rodriguez-Sanchez et al., 2016). Almost all the electrical and electronics engineering and technology programs include the course with the aim to expose the student to the current embedded system or microcontroller (Alavi & Meehan, 2019; Chancharoen et al., 2015; Karunaratne, 2019; Martelaro et al., 2020; Martínez-Santos et al., 2017; Sirkin et al., 2019;

Zakaria, 2017). They start with the basic programming and microprocessor before the embedded system course.

Fundamentally, all electronic devices or equipment use an embedded system as a brain for the devices. It can be in the form of a microcontroller or microprocessor, and the difference between both is that microprocessors are more complex than the microcontroller (Brand et al., 2011; Karvinen & Karvinen, 2018). On top of that, the microcontroller evolved quite fast and intensively used compared to the microprocessor. This disruptive evolvement comes in many ways, including programming language, program loading, architecture, hardware integration, and the most extreme is cheap.

The introduction of the open-source electronic platform Arduino in early 2010 hits the industry. This game-changer has remained relevant since the date, evolved, and is the market trendsetter for the embedded system platform. This simple platform gets a big highlight by IEEE via a sensible title to describe the platform's ease against the existing and available solution in the market during the early stage. Rather than required understanding multiple machine languages, the Arduino has simplified this issue thoroughly. The elements of inexpensive, open-source hardware, internal programmer (Burner), ease programming, open-source software, collaborative library, and IDE Software operating on any operating system make the solution lead the market at that time until today.

The solution focuses on the design output rather than understanding the coding, architecture, and other tedious designers before a solid solution can be developed. Globally, most universities have started to adopt Arduino in their course, and this has been witnessed from numerous articles written on this as reported in (Abidin et al., 2018; A Abidin et al., 2015; Al Junid et al., 2020; Hadi et al., 2020; Bakri et al., 2015; Abdul Razak, 2020; Al Junid et al., 2018; Rashid & Al Junid, 2014).

Most of the articles report the content and the experience of teaching embedded system courses (Karunaratne, 2019; Martelaro et al., 2020; Martínez-Santos et al., 2017; Mutalib Al Junid et al., 2018; Rodriguez-Sanchez et al., 2016), while some articles highlight the strategy towards improving the courses delivery and student learning experience (Alavi & Meehan, 2019). However, analysis over a decade on microcontroller selection for teaching and learning embedded system courses is new and has not been highlighted in any study before to capture the justification and reasoning in the selection.

Therefore, this article documented the type of microcontroller used to deliver the course offered at the school of electrical engineering, Universiti Teknologi MARA, since 2010. This article highlighted the overview of the embedded system course and the demand in the introduction part for providing a complete understanding of the study gaps. The methodology highlights the workflow in investigating the microcontroller used in the course from 2010 until 2019. The result from the documentation search related to the microcontroller selection is highlighted and justified in this part. In the conclusion part, the finding is summarised the important finding discovered from the study.

Methodology

This study was carried out at the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Shah Alam, Malaysia, for the Bachelor of Electronics Engineering degree program. The study only focused from 2010 until 2019 based on the documented evidence and report where the report and document review were chosen to get a clear picture to get the selection reasoning or justification during the selection, and the decision was made. The documents which were reviewed in this study are course information, course outline, student report, Continuous Quality Improvement (CQI) report, Industrial Advisory Panel (IAP) report, and Engineering Accreditation Council (EAC) report. The overview of the document selection is shown in Figure 1.

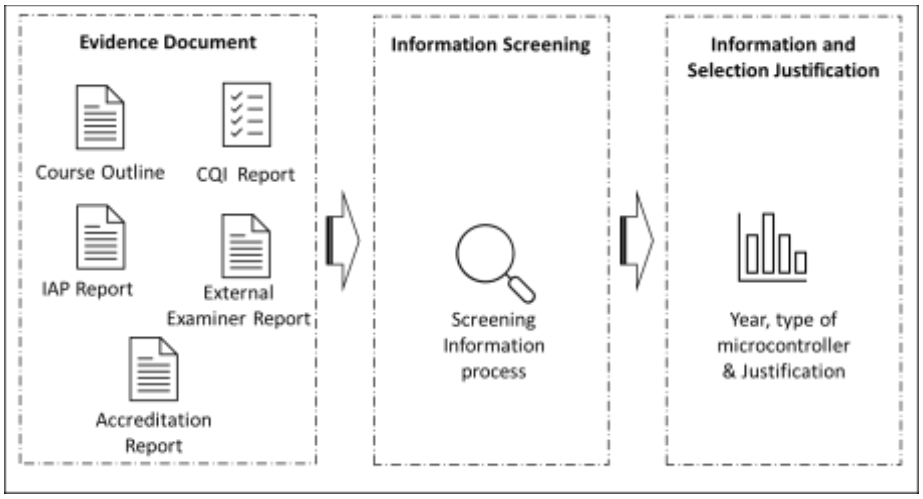

Figure 1. The selection process for assessing the microcontroller selection justification and reasoning.

Figure 1 shows that all documents related to the embedded system design and interfacing course offered to the student at semester 6 were analysed. The inclusion and exclusion criteria are set for the assessment. The inclusion criteria were set to avoid unbiased results; [1] the data to be collected is from 2010 to 2019 and [2] the type of microcontroller used for teaching and learning embedded system and interfacing course. In contrast, the exclusion criteria were: [1] the data or report before 2010 and after 2019 not be taken for this assessment and [2] the type of microcontroller used in other subjects than embedded system and interfacing.

Result

Evidently, the embedded system and interfacing course with the code ELE651 is offered to all students in semester 6 for the Bachelor of Electronics Engineering (Hons.) at the School of Electrical Engineering, Universiti Teknologi Mara, Malaysia. The detail for the course information is listed in Table1.

Table 1.
Embedded System and Interfacing Course Information

No	Parameters	Information
1	Course Name	Embedded System and Interfacing
2	Course Code	ELE551
3	Credit Hour	3 Credit (3 hours lecture and 1-hour tutorial)
4	Assessment Method	Assignment, lab exercise, group project, 2 test
5	Course Description	This course will expose students to the fundamental of embedded system hardware and firmware design.
6	Transferable Skills	1) Solve engineering problem 2) Work independently
7	Syllabus Content	1. Introduction of Microcontroller 2. Sensor and Actuator 3. Basic Control System 4. Wireless Communication
8	Course Outcome	1) Describe microcontroller capability in various applications. 2) Explain the architecture, assembly language and application of the microcontroller 3) Design embedded system based on the given problem statement
9	Year of Start Offering	2010
10	Type of Microcontroller Use	Arduino UNO, Arduino MEGA, Intel Galileo, ESP32, Microchip PIC16F877A
11	Programming Language	C++, Assembly Language

As tabulated in Table 1, the course is a core course with three credit hours which the prerequisite is to pass the microprocessor design course offered to the student in semester 4. The overview of the embedded system design course is summarised in Table 1.

Based on the information obtained, the summary of the microcontroller according to the year is shown in Figure 2.

Figure 2: The type of microcontroller used in the course based on the course offered year

The course used Microchip-based microcontrollers from 2010 until 2011, specifically PIC16F877A. From 2012 onwards, the course remained using the Arduino UNO board, while in 2015, the course added the Intel Galileo board as a microcontroller board; however, it only remained until 2016. In 2019, the course started using ESP32 as an optional board.

Based on the document review, the microcontroller selection depends on the cost, facilities, material support, and industry demand. Three main components influence the selection. Moreover, the complexity of the microcontroller is the primary concern since some of the microcontrollers require additional tools for programming, which incurred in cost. In addition, the cheap solution for both hardware and software also influence the selection process. Based on the document assessment, the summary finding is tabulated in Table 2.

Table 2.
Selection factors in microcontroller selection

Year	Microcontroller Type	Selection Factors					
		Cost	Facilities	Industry Suggestion	Support	Simple	Robust
2010	Microchip PIC16F877A	✓	✓				✓
2011	Microchip PIC16F877A	✓	✓				✓
2012	Arduino UNO	✓	✓	✓	✓	✓	✓
2013	Arduino UNO	✓	✓	✓	✓	✓	✓
2014	Arduino UNO	✓	✓	✓	✓	✓	✓
2015	Arduino UNO	✓	✓	✓	✓	✓	✓
	Arduino Mega	✓	✓	✓	✓	✓	✓
	Intel Galileo		✓	✓		✓	
2016	Arduino UNO	✓	✓	✓	✓	✓	✓
	Arduino Mega	✓	✓	✓	✓	✓	✓
	Intel Galileo		✓	✓		✓	
2017	Arduino UNO	✓	✓	✓		✓	✓
	Arduino Mega	✓	✓	✓	✓	✓	✓
2018	Arduino UNO	✓	✓	✓	✓	✓	✓
	Arduino Mega	✓	✓	✓	✓	✓	✓
2019	Arduino UNO	✓	✓	✓	✓	✓	✓
	Arduino Mega	✓	✓	✓	✓	✓	✓
	ESP32	✓	✓	✓	✓	✓	✓

As recorded in Table 2, the investigation shows that the Arduino based board were getting higher selections due to the cheap, simple, recommended by industry, and support. However, the Intel Galileo has been used based on the industry recommendation, but due to the cost, durability, and technical robustness, the board cannot be further utilised due to malfunction issues. On the other hand, the PIC16F877A was only used for the early two years before the Arduino based was introduced in 2012.

Conclusion

Evidently, the embedded system course is a purely technical based course in which the microcontroller plays an important role in the student technical knowledge exposure and learning experience. The cost is extremely important in the microcontroller selection compared to the rest. However, the robustness and facilities are the second factors influencing the selection, which are generally second after the cost. Finally, the compilation of the selection justification is extremely important for the faculty or school to get the proper guide to decide for the future devices to be selected for the subject based on the previous pattern and experience recorded.

Acknowledgements

The authors wish to acknowledge the School of Electrical Engineering, College of Engineering, Universiti Teknologi MARA, Malaysia, for the information and facilities support towards completing this study.

References

Abidin, A. F. Z., Jusoh, M. H., Junid, S. A. M. A., & Razak, A. H. A. (2018). Development of low power wireless fluxgate magnetometer instrumentation for real-time geomagnetic monitoring. *Journal of Fundamental and Applied Sciences*, *9*(5S), 481. https://doi.org/10.4314/jfas.v9i5s.34

Al Junid, S. A. M., Thani, S. O. K., & Abdul Rashid, Z. (2020). Trees' Cooling Effect on Surrounding Air Temperature Monitoring System: Implementation and Observation. *International Journal of Simulation Systems Science & Technology*.
https://doi.org/10.5013/IJSSST.a.15.02.10

Alavi, Z., & Meehan, K. (2019). Enhancing a control systems design course by using experiential learning model. *ASEE Annual Conference and Exposition, Conference Proceedings*. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078718803&partnerID=40&md5=fea30489699e152fc7814aafc9d5defd

Brand, E. A., Honig, W. L., & Wojtowicz, M. (2011). Intelligent systems development in a non engineering curriculum. *ITiCSE'11 - Proceedings of the 16th Annual Conference on Innovation and Technology in Computer Science*, 48–52.
https://doi.org/10.1145/1999747.1999764

Chancharoen, R., Sripakagorn, A., & Maneeratana, K. (2015). An Arduino kit for learning mechatronics and its scalability in semester projects. *Proceedings of IEEE International Conference on Teaching, Assessment and Learning for Engineering: Learning for the Future Now, TALE 2014*, 505–510. https://doi.org/10.1109/TALE.2014.7062606

Karunaratne, M. (2019). Impact of embedded systems course on undergraduate capstone projects. *ASEE Annual Conference and Exposition, Conference Proceedings*.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85078779243&partnerID=40&md5=da645850027a8ca355e7b028a863af87

Karvinen, K., & Karvinen, T. (2018). IoT rapid prototyping laboratory setup. *International Journal of Engineering Education*, *34*(1), 263–272.

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85042553737&partnerID=40&md5=a40922e53d96a2c342b0c05f479a867c

Malaoui, A. (2016). Low cost pedagogic device for practical works using embedded system. *Proceedings of IEEE/ACS International Conference on Computer Systems and Applications, AICCSA*, *2016-July*. https://doi.org/10.1109/AICCSA.2015.7507160

Martelaro, N., Zamfirescu-Pereria, J. D., Goedicke, D., Sirkin, D., & Ju, W. (2020). Make this! introduction to electronics prototyping using arduino. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3334480.3375052

Martínez-Santos, J. C., Acevedo-Patino, O., & Contreras-Ortiz, S. H. (2017). Influence of Arduino on the Development of Advanced Microcontrollers Courses. *Revista Iberoamericana de Tecnologias Del Aprendizaje*, *12*(4), 208–217.

https://doi.org/10.1109/RITA.2017.2776444

Al Junid, M. S. A., Hussaini, Y., Osman, F. N., Abdul Razak, A. H., Idros, M. F., & Halim, A. K. (2018). Evaluation of Embedded System Component Utilised in Delivery Integrated Design Project Course. *IOP Conference Series: Materials Science and Engineering*, *341*, 012029. https://doi.org/10.1088/1757-899X/341/1/012029

Rashid, Z. A., & Al Junid, S. (2014). *Trees' cooling effect on surrounding air temperature monitoring system: Implementation and observation*. *15*, 70–77.

https://doi.org/10.5013/IJSSST.a.15.02.10

Rodriguez-Sanchez, M. C., Torrado-Carvajal, A., Vaquero, J., Borromeo, S., & Hernandez-Tamames, J. A. (2016). An Embedded Systems Course for Engineering Students Using Open-Source Platforms in Wireless Scenarios. *IEEE Transactions on Education*, *59*(4), 248–254. https://doi.org/10.1109/TE.2016.2526676

Sirkin, D., Ju, W., & Martelaro, N. (2019). Make this! Introduction to electronics prototyping using arduino. *Conference on Human Factors in Computing Systems - Proceedings*. https://doi.org/10.1145/3290607.3298807

Zakaria, M. F. (2017). Arrow-bot: A Teaching Tool for Real-Time Embedded System Course. *MATEC Web of Conferences*, *87*. https://doi.org/10.1051/matecconf/20178705001