Journal of Engineering Research (ERJ)
Vol. 7– No. 5, 2023
©Tanta University, Faculty of Engineering
ISSN: 2356-9441 https://erjeng.journals.ekb.eg/ e ISSN: 2735-4873

Experiential Learning in Computer Engineering using Advanced Logic Design Peripherals

Omer Alkelany[1]

[1]Acting Vice Dean for Graduate Studies, and Scientific Research, Horus University- Egypt – email: oalkelany@horus.edu.eg

***Abstract*- One of the main tracks of research is about Low-cost computing devices in engineering educations. This track face the problem that conventual methods are either too trivial demonstrative educational examples, or too abstracted that it hides away the necessary details students should learn, or too complex industry grade demonstrations. This research targets to utilize lost cost computing devices, and produce multiple step-by-step, educational components for university level. It relies on the experiential learning methodology via generating multiple level educational components for Field Programmable Gate Array (FPGA) devices. To inspire creativity, two Advanced experiences were demonstrated using a 5 mega pixel camera, and a 4.3 inch touch screen module, connected to same FPGA board. A comparison between conventional methods and proposed methods is also presented. Due to its advantages, we disseminate this technique to researchers universities in the nation and abroad.**

***Keywords*- Higher education enhancement, Technology in education, Field Programmable Gate Arrays (FPGA)s, Prototype Laboratory development, Digital camera peripheral, Touch sensitive Liquid Crystal Display peripheral.**

I. INTRODUCTION

Introduced almost 4 decades ago, Field Programmable Gate Arrays (FPGA), grew from having too limited capability to devices that are capable of modeling millions of programmable gates (or reconfigurable logic). The FPGA market share today is in the billions of US dollars [1, 2]. The FPGA devices allow designers to configure these different reconfigurable logic components, and allow them to change them late as desired. Specifically, FPGA manufactures use SRAMs to allow configurable routing of wires as well. To imagine that, two intersecting wires can be set to connect or be insulated from each other by means of a binary gate to allow them so. Hence, the whole FPGA chip can be configured by knowing exactly what each "bit" needs to be in each wire crossing, and each LUT. This whole group of bits is called the configuration file. The term "Programmable" in FPGA name actually means loading this configuration file to its SRAM, so that it can operate as designed. It is unlike programming a computer in terms of serios of sequential instructions translated to binary code. Once the FPGA gets its configuration file loaded, it does not actually execute a program. It is implementing logic described by those LUTs and connections on its reconfigurable resources.

Logic circuit designers are now equipped with sophisticated design tools, which make the FPGA a feasible choice for implementing, testing, evaluating multitude of integrated circuit components. Furthermore, FPGA technology allows designers to use already fabricated integrated circuits to implant logic circuits and changed them later. Thus, FPGAs become a perfect technology for educators who are involved in reconfigurable hardware design courses.

Instructors using Experiential learning need to only show directions of how to accomplish a task, and not giving the learners all the details of how to take the route to the desired destination [3]. Thus, it makes learning an experience (i.e., not just perform an experiment) that moves beyond the classroom instruction and allows students the opportunity to draw conclusions, and being more involved in their own learning process.

Experiential Learning is thus considered as Learning by reflection on Doing [4-12]. It is not a new concept, and various philosophers stressed it in their teachings. It was conceptualized by Aristotle about Ethics as "for the things we have to learn before we can do them, we learn by doing them (first!)" [13]. However, in the 1970s, David A. Kolb developed a fundamental modern model of experiential learning [14]. According to Kolb, [15-16] the learner must be actively involved in the experience; reflect on the experience; analyze the outcomes; and perform decision making and problem-solving skills in order to use the new ideas gained from the prior experience. In this process, instructors to give constructive feedback to the learners, but they should not rush to provide the answer [17-19], especially when creative abilities are to be developed (critical thinking, design, synthesis, etc.), and particularly when there is not a single right answer. They will use their experience to judge or evaluate an outcome of a targeted component and share it with the learners [20-21].

Experiential learning was used in different fields of engineering education. For example [22], it was used via hardware emulators, and FPGA were used in latter stage of complex multi-part designs. Also, in 2020, two different comparative studies for experiential learning were done in two different universities in China, and New Zealand considering virtual reality applications, concluded that it enhances learning experience [23,25]. Furthermore, researchers investigated the incorporation of experiential learning at a Canadian university, in 2017, but they implemented it in a single engineering course, without FPGAs, and thus results were limited [25]. Recently, a research team in Horus University-Egypt adopted the use of FPGAs in experiential learning [26, 27].

doi: 10.21608/erjeng.2023.233280.1221

Journal of Engineering Research (ERJ)
Vol. 7– No. 5, 2023
©Tanta University, Faculty of Engineering
ISSN: 2356-9441 https://erjeng.journals.ekb.eg/ e ISSN: 2735-4873

II. Camrea learning by Experience

The author founded the Experiential Learning Research Lab in the Faculty of Engineering at Horus University-Egypt via funds made available both internally and externally. Figure 1 shows an angle of this lab, where stations are set to design different students experiences. [26, 27]

Figure 1: The Experiential Learning Research Lab (EXL-Research) showing multiple stations

Of the acquired components in this lab are the Altera DE2 board, shown in Figure 2, and the TRDB_D5M board [31], shown in Figure 3, which provides 5 Mega Pixel Digital Video when connected to FPGA boards such as the Altera DE2-70 / DE2 boards.

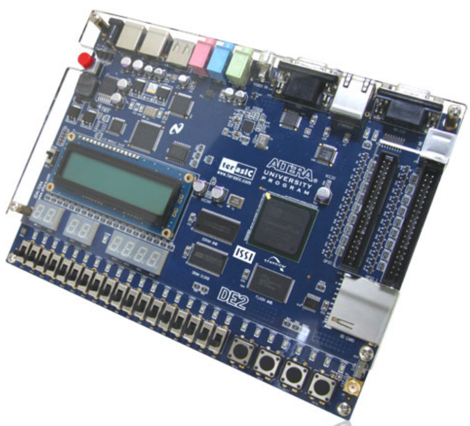

Figure 2:The Altera DE2 board

The DE2 /VGA monitor/ D5M Camera experiential learning setup is as shown in Figure 4. We ought to connect the monitor to the DE2 board's VGA port, and the D5M to the 40-pin GPIO port of the board (the outer right black port). This will allow a *Learning by Experience* which will involve the following:

Figure 3: The TRDB_D5M 5 Mega pixel camera

1- Students need to connect the VGA output of the DE2 board to a VGA monitor. If the camera is not initialized, then the VGA monitor would display an output as shown in Figure 5.

2- Once the student presses the push button KEY0 on the DE2 board, the camera interface is reset, and it should start capturing video stream. The captured stream is routed to the attached monitor, as shown if Figure 6.

3- Students can then press KEY3 to switch the camera to the FREE RUN mode.

4- If KEY2 is pressed, a snapshot of the free video is taken; and if KEY3 is pressed again to switch back to FREE RUN mode.

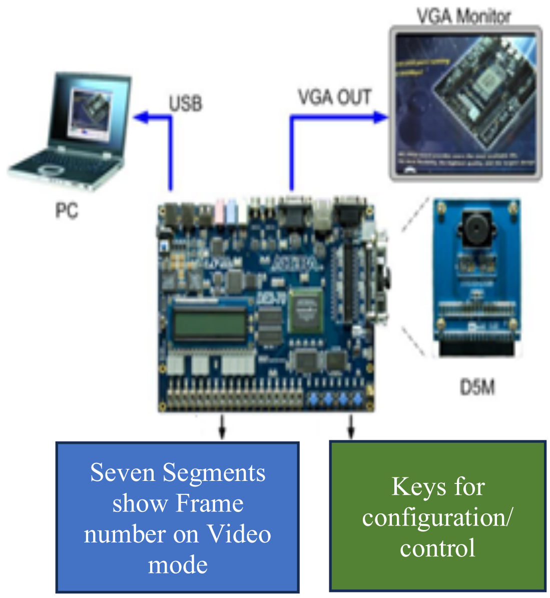

Figure 4: The DE2/Monitor/Camera experiential learning setup

doi: 10.21608/erjeng.2023.233280.1221

Journal of Engineering Research (ERJ)
Vol. 7– No. 5, 2023
©Tanta University, Faculty of Engineering
ISSN: 2356-9441 https://erjeng.journals.ekb.eg/ e ISSN: 2735-4873

Figure 5: The DE2 board, with the VGA monitor, and the D5M Camera (Camera not initialized)

Figure 6: The DE2 board, with the VGA monitor, and the D5M Camera (Camera initialized)

5- Students can then use the KEY1 to set the exposure time for brightness adjustment of the image captured. When SW[0] is set to Off, the brightness of image will be increased as KEY1 is pressed longer. If SW[0] is set to On, the brightness of image will be decreased as KEY1 is pressed shorter, and so on.
6- Finally, students can set the SW[16] to On position, and the captured image will be enlarged with KEY0 and KEY3 pressed in order.

Based on this Cyclone II FPGA boards, the instructor may further challenge the students by projects of high complexities. Examples include integrating algorithms for edge detection of the objects in the motion picture, or performing color correction, or image compression of the still captured images. Thus, students will need to use more capabilities of the FPGA design tools. Also, for advanced courses, the same project can be extended to send the outputs to a network interface, thus using a web browser, and a microprocessor on the FPGA chip and so on. In those later experiences, students will need to learn more about Hardware Description Languages (HDL), such as Verilog or VHDL together with Schematic editors, in-chip logic analyzers, functional simulations, and timing simulations.

III. Touch Screen learning by Experience

Another related experience is the use of the Touch LCD module. A 4.3 inch touch screen (TRDB_LTM) module [32] shown in Figure 7, is also found in the experiential learning lab mentioned before. After proper configuration of the FPGA board, students can touch the bottom left corner and top right corner of the LTM panel to display the next and previous photos respectively. Also, the seven segments are set to indicate the coordinates of the touch, should the user experiences touching other than those designated corners. Figures 8 and 9 show example of possible results.

Figure 7: A 4.3 inch touch screen TRDB_LTM module

doi: 10.21608/erjeng.2023.233280.1221

Figure 8: A possible response after touching one corner

Figure 9: : Another response after touching one corner

IV. FPGA BASED EXPERIENTIAL LEARNING COMPARISON WITH CONVENTIONAL METHODS

Conventual ways to implement basic logic circuits include:

- Logic simulation
- Discrete component implementations
- Ready off-the-shelf logic blocks

Int the following we list advantages and disadvantages of these choices as they compare with

- Modern, FPGA based logic circuit implementations

Logic simulation: This is typically a computer based simulation of the logic circuits (such as LogiSim, ModelSim, etc). Although very useful to illustrate teaching concepts, but they fail to give the necessary physical experiences, and students may still find it not convincing that their design will actually work.

Discrete component implementations: This is straight forward buy, and try approach. Usually, students are asked to acquire parts on their own, and build the circuit. Most of the time, due to lack of prior experiences, students break many parts, and may get frustrated from having to buy more parts to replace failed ones. Also, it requires a very thorough attention to details of all wirings, which can be sometimes too time consuming and also frustrating.

Ready off-the-shelf logic blocks: This tries to remedy the problems of previous choice, but for its simplicity, fails to give the student the proper hardware experiences of industrial implementation technology.

Furthermore, none of the implementation methods used above are actually used in the computer logic design industry today.

FPGA technologies have reached a maturity level that is used in industry and can be also used in multi level (i.e., basic to complex) design circuits.

V. CONCLUSIONS

In this paper, the we presented two advanced demonstrations of design experiences using a 5 Mega pixel camera, and a 4.3 inch touch screen module for the experiential learning pedagogy. Detailed step by step illustrations were give, so that instructors can use it to duplicate the experiences and benefit from them. Furthermore, we compared such developed

doi: 10.21608/erjeng.2023.233280.1221

experiences with conventual methods, showing that experience learning, even in its basic form resolves the problems found in traditional teaching.

VI. Acknowledgment:

Funding: This research is supported by the Egyptian Science Technology Development Fund-research proposal #45945 for the years 2022-2024.

Conflicts of Interest:
All authors declare that they have no conflict of interest regarding this research paper and that they comply with research ethics.

References

[1] -, "FPGA Design – A Brief History," July, 18th, 2010, https://www.enventure.com/blog/fpga-design-a-brief-history/, accessed August, 2023.
[2] Kevin Wible, "What is an FPGA and how does it Work?," https://www.cardinalpeak.com/blog/curious-about-what-an-fpga-is-and-how-it-actually-works, accessed August, 2023.
[3] Hawtrey, Kim. "Using Experiential Learning Techniques". Journal of Economic Education, volume 38, issue. 2, pp. 143-152, 2007.
[4] Felicia, Patrick. Handbook of Research on Improving Learning and Motivation. ISBN 978-1609604967, 2011.
[5] MIT Sloan Management, "Action Learning - How does it work in practice?", Why back mission site, 2016.
[6] -, The Power of Experiential Learning, 4-H Cooperative Curriculum System. 2016.
[7] -, The Out of Eden Walk: An Experiential Learning Journey from the Virtual to the Real, http://www.edutopia.org/blog/out-of-eden-experiential-learning-homa-tavangar, January 3, 2014. Retrieved 2020.
[8] MIT Sloan, Action Learning - How does it work in practice? http://mitsloan.mit.edu/mba/program-components/hands-on-learning/, retrieved 2021.
[9] -, The Power of Experiential Learning, 4-H Cooperative Curriculum System, http://njaes.rutgers.edu/learnbydoing/ . retrieved 2020.
[10] Beard, Colin (2010). The Experiential Learning Toolkit: Blending Practice with Concepts. p. 20. ISBN 9780749459345, https://books.google.com/books?id=DAhYlaZhRI8C&pg=PA20 retrieved 2020.
[11] Itin, C. M., Reasserting the Philosophy of Experiential Education as a Vehicle for Change in the 21st Century. The Journal of Physical Education 22(2), p. 91-98, 1999.
[12] Breunig, Mary C., "Teaching Dewey's Experience and Education Experientially". In Stremba, Bob; Bisson, Christian A. (eds.). Teaching Adventure Education Theory: Best Practices. p. 122. ISBN 9780736071260, 2009.
[13] Nicomachean Ethics, Aristotle, Book 2, D.P. Chase translation ,1911.
[14] Dixon, Nancy M.; Adams, Doris E.; Cullins, Richard. "Learning Style". Assessment, Development, and Measurement. p. 41. ISBN 9781562860493, 1997.
[15] Kolb, D., Experiential Learning: experience as the source of learning and development. Englewood Cliffs, NJ: Prentice Hall. p. 21, 1984.
[16] Kolb, D., Experiential Learning, http://www2.le.ac.uk/departments/gradschool/training/resources/teaching/theories/kolb, 2012.
[17] Merriam, S. B., Caffarella, R. S., & Baumgartner, L. M., Learning in adulthood: a comprehensive guide. San Francisco: John Wiley & Sons, Inc., 2007.
[18] Moon, J., A Handbook of Reflective and Experiential Learning: Theory and Practice. London: Routledge Falmer. p. 126., 2004.
[19] Kolb, D,. Experiential Learning as the Science of Learning and Development. Englewood Cliffs, NJ: Prentice Hall.1984.
[20] Chickering, A., Experience and Learning. New York: Change Magazine Press. p. 63., 1977.
[21] Hutton, M., Learning from action: a conceptual framework, in S. Warner Weil and M. McGill (eds) Making Sense of Experiential Learning. Milton Keynes: SRHE/Open University Press. pp. 50–9, p. 51, 1980.
[22] J. O. Hamblen, H. L. Owen, S. Yalamanchili and Binh Dao, "An undergraduate computer engineering rapid systems prototyping design laboratory," in IEEE Transactions on Education, vol. 42, no. 1, pp. 8-14, doi: 10.1109/13.746325, 1999.
[23] C. Zhou, H. Li and Y. Bian, "Identifying the Optimal 3D Display Technology for Hands-On Virtual Experiential Learning: A Comparison Study," in IEEE Access, vol. 8, pp. 73791-73803, doi: 10.1109/ACCESS.2020.2988678, 2020.
[24] E. Rho, K. Chan, E. J. Varoy and N. Giacaman, "An Experiential Learning Approach to Learning Manual Communication Through a Virtual Reality Environment," in IEEE Transactions on Learning Technologies, vol. 13, no. 3, pp. 477-490, 1, doi: 10.1109/TLT.2020.2988523, 2020.
[25] Hajshir mohammadi, "Incorporating Experiential Learning in Engineering Courses," in IEEE Communications Magazine, vol. 55, no. 11, pp. 166-169, doi: 10.1109/MCOM.2017.1700373, 2017.
[26] Omer Alkelany, Hatem Khater, Mohamed Kamal, Hosam E. Mostafa, "Preliminary Evaluation of Experiential Learning in Engineering Pedagogy for Undergraduate Students Learning Logic Design Concepts" Proceedings of the First International Conference on Engineering Solutions toward Sustainable Development (ESSD-2023).
[27] Omer Alkelany, Hatem Khater, Mohamed Kamal, Hosam E. Mostafa, "Survey and Evaluation of Applied Modern Engineering Pedagogy" Proceedings of the First International Conference on Engineering Solutions toward Sustainable Development (ESSD-2023).
[28] -, Data sheet for Altera Cyclone II family, https://datasheet.octopart.com/EP2C5T144C8-Altera-datasheet-7627975.pdf, pages 7-8 of 168, accessed August 2023
[29] Terasic, Altera DE2 board: https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=53&No=30,Accessed August 2023
[30] Altera DE2 Pin Table: https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=53&No=30&PartNo=4#contents, Accessed August, 2023
[31] Terasic D5M camera module, https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=68&No=281, Accessed 2023.
[32] Terasic LTM touch screen module, https://www.terasic.com.tw/cgi-bin/page/archive.pl?Language=English&CategoryNo=68&No=213 Accessed 2023.