ISSN 2229-5518

Developing Fourth Industrial Revolution Ready Electronics Engineers in a Problem-Oriented Project-Based Learning Environment: A Theoretical Framework

By

Terungwa Stephen Akor, Demenongu Alfred Tyav, Mlahaga Michael Iorbee, Kwaghkar Boniface Nande

Abstract - This article aimed at developing a Problem-Oriented Project-Based Learning (POPBL) theoretical framework for the development of the Fourth Industrial Revolution (4IR) skills in electronics engineering. To this effect, content analysis and synthesis of related literature, models and frameworks were carried out based on the title and the keywords of the article. The content analysis and synthesis were carried out on the concept and the skills needs of the 4IR; electronics engineering in the era of 4IR; POPBL components, processes and related theories. The literature analysis revealed that, although 4IR has come with numerous benefits, it still poses a threat to the economic development of nations and employees that are not adequately prepared for it. The study also revealed that electronic engineering is the anchor of all the driving forces of the 4IR. The literature also showed that POPBL has the potentials of developing the top skills of the 4IR like problem-solving, teamwork, creativity, critical thinking, decision making and so on. The resulting theoretical framework which is a systematic and logical hybrid of the analysed literature, frameworks and models has the potentials of producing electronics engineers with the requisite skills as demanded by the 4IR.

Keywords: Fourth Industrial Revolution, Electronics Engineering, Problem-Oriented Project-Based Learning, and Theoretical Framework.

1.0 Introduction

The evolution of the fourth industrial revolution (4IR) has presented numerous benefits, opportunities as well as challenges at a higher frequency more than any other previous revolution. The 4IR is a sharp contrast from the previous revolutions because, unlike the previous revolutions where technology replaced skilled workers, technologies of the 4IR complement workers with high skills while replacing workers with low skills. The chance of any economy to participate in manufacturing and production in the 4IR depends on the availability of relevant skills. As a result of the replacement of low skilled workers in manufacturing, the chances are that over 66% of developing countries' jobs are at risk. This shows that most countries in Africa are at the risk of losing around 44 - 50% of their jobs to automation (Naudé, 2017).

The era of 4IR has brought a fundamental shift across the industries in areas of design, production, sales, marketing, and delivery systems. According to (Maynard, 2015), 4IR has four major characteristics: Homo sapiens developed into “phono sapiens” with most industrial business activities dominated by smartphones; creation of knowledge is with the collection, categorization, and analysis of big data sets; software’s in artificial intelligence now compete with human intelligence where AI robots replace many human routine jobs and; Business platforms get more popular with mass customization and personalized production being realized.

Electronic engineering is obviously, the dominant driving force of the 4IR as can be seen in the major drivers of the revolution advanced robotics, additive manufacturing (3D printing), augmented reality, horizontal/vertical integration, big data/analytics, cloud/cyber-security, simulations, and industrial internet. This indicates that the production of high-quality electronic engineers concerning the demands of the 4IR can significantly boost the evolution of the revolution. This calls for the utilization of the most appropriate and systematic instructional approach for the training of 21st-century electronics engineers hence, Problem-Oriented Project-Based Learning (POPBL).

2.0 The Fourth Industrial Revolution (4IR)

Current changes in the world of work are frequently depicted as the fourth industrial revolution, which is characterized by key technologies such as genetics, artificial intelligence, cloud computing, nanotechnology, biotechnology, and 3-D printing, among others (Hirschi, 2018). According to Gleason (2018), many existing jobs are automated, the figure and areas where these jobs exist can be ascertained with time. Technological developments that are facilitated by innovations in big data, machine learning, and cloud computing have greatly influenced automation. The meaning of being human is being changed by the evolving technological processes which affect how we live and execute our jobs. Although new jobs are emerging, there

ISSN 2229-5518

is no tendency for any economic growth without corresponding job opportunities.

The cyber-physical systems (CPSs) involved in the 4IR are taking over most of the existing jobs around the world (Baker, 2016). The change mechanisms are so complex and swift in action with the CPSs at the core of the innovations being experienced globally. Today the technology is new but advancing very fast. Driving trucks, cars, or lawn mowers are no longer a human job. This has significant implications for economies all over the world.

In terms of skills demand, 4IR requires specific skills that differ from the skills that were saleable in the third industrial revolution where information technology was the fundamental driver. These skills are critical thinking, emotional intelligence, people management, judgment, cognitive flexibility, negotiation, as well as knowledge management and production. Gray (2016), observed that, in the next five year, over 35% skills that are relevant in the contemporary workforce will become obsolete By the year 2020, the 4IRis likely to introduce us autonomous transport and advanced robotics, advanced materials, artificial intelligence (AI) and machine learning, genomics, and biotechnology. All these innovations will transform our way of living, and the way we execute our jobs as some existing jobs will disappear with the emergence of new ones that do not exist today. The demand will be for the emerging workforce to align the skill set to keep pace.

Creativity will become among the top three skills to be demanded by employers. With the roll down of new products, emerging technologies and new methods of job execution, workers have to be more creative to fit into the changes. Even though robots may help to an extent reach the desired destination faster, their creativity cannot be as humans. Whereas flexibility and negotiation were high on the list of skills around 2015, it is expected that by 2020 they will begin to relegate from the top 10 due to decision making by machines with masses data usage. A survey carried out by the World Economic Forum's Global Agenda Council on the Future of Society and Software indicates that AI machines are expected to form part of the board of directors of companies by 2026. In a related sense, active listening which is considered a major skill today will vanish from the list of top 10. Emotional intelligence is not among the top 10 now, will emerge among the top needed skills by all.

The disruption being experience in the industry as a result of innovations to a great extent depends on the industry itself. For example, the global media/entertainment had already experienced a radical change in the last five years. The service in the finance and investment sector, however, is yet to experience the radical transformation as workers in manufacturing and sales need relevant skills especially, technological literacy. Although mobile internet and cloud computing technology are already impacting our work life, some advances are ahead of others. Artificial intelligence, advanced materials, and 3D printing are still in their infant stages of use, but the pace of change likely to be fast. All these immensely depend on electronics which is the bed-rock of the 4IR driving forces.

3.0 Electronics Engineering (EE)

Electronics engineering which is a subfield of electrical engineering involves the study of circuits and devices that regulate the electrons flow for the processing information and performance of various tasks using electricity(Zhang, Hansen, & Andersen, 2015). According to Medrano, Ubé, Plaza, & Blesa (2002), electronics engineers cause the flow of electric current through manipulated medium to produce various results and solutions to human needs. These manipulations are made through the manufacture of various semiconductors with specific concentrations, shapes, sizes, and structures (Reis, 1997). The work of an electronics engineer is to continuously improve and enhance the quality of human life by developing new equipment and devices in all fields of life. The impact of electronics engineering can be felt in areas like medicine, engineering, education, entertainment, communication, transportation, security, construction, defence, warfare and many other areas (Medrano et al., 2002; Scherz, 2013).

According to Waterford Institute of Technology, (2012), "Electronic engineering is a rapidly advancing profession and is the driving force behind the development of the world's information technology. Electronic engineers create, design and develop everyday devices like mobile phones, portable music devices, and computers. Electronic engineering offers a broad range of exciting career challenges including producing innovations and developments in telecommunications, robotics, computing hardware, and power and electrical equipment". According to Waterford Institute of Technology, (2012), Students of electronics engineering can specialize in various areas which include Audio-visual and Light electronic Equipment: Control Systems and Automation: Microelectronics, and Telecommunication

Electronics Engineering is a captivating field of engineering that brings rewarding, enriching and challenging opportunities. The 21st-century electronics technologies have made electronics products so inevitable that the usage and application go even beyond the food we consume thus, making the field as demanding as healthcare and education (Ghani, 2018). Electronics engineers have produced and are still developing systems and devices which could help millions of people in diverse aspect like communication, entertainment, security, healthcare, information and so on. According to Loquias (2015), electronic engineering is an exceptional field of engineering graduates have good prospects, high starting salary, global opportunities, high demand, usefulness to society, cutting edge technology, and above all, the potentials to drive the 4IR hence, the call for the most suitable teaching method that could lead to the development of the 4IR skills.

4.0 Problem-Oriented Project-Based Learning (POPBL)

ISSN 2229-5518

Problem-Oriented project-based Learning (POPBL) aims at providing solutions to the problems of the society as well as enhances learners' creativity through the initiation and execution of a project. The experience from the process promotes learners' acquisition of knowledge from the research, findings, and discoveries (Mcloone, Lawlor, & Meehan, 2014). This method is learners' centred, therefore, it doesn't require the memorization of formulas or theories but enhances the acquisition of creative and analytical thinking through the analysis information acquired to solve the existing problem (Hernandez, Ravn, & Valero, 2015; Ibrahim & Halim, 2014). As a problem cantered process, POPBL focuses on tailoring the content of the curriculum around the problem setting instead of subject or courses (Uziak, 2016). The process engages learners with complex settings with the skills and information needed to manage a given situation (Danielsen & Lerche, 2010; Masek, 2017).

According to Danielsen & Lerche, (2010), POPBL is characterized by active learning participation and cooperative groups' project work, guided participation in negotiation between learners and the instructor as a facilitator and supervisor. It enhances the cross-disciplinary acquisition of knowledge across academic fields. The take-off point for a POPBL is the inquiry stage where students or learners groups investigate a problem is not known to them thereby, provoking their thoughts for action (Lehmann, Christensen, Du, & Thrane, 2008; Mcloone et al., 2014; Ruhizan M. Yasin & Rahman, 2011). In the process of attempting a solution to a given problem, groups embark on organized and logical dialogue approach through the collection relevant materials and information; utilize applicable theories and methods as guides to systematically transform and orchestrate the materials or information to discover and elucidate the problem domain as well as research questions. This is followed by coming up with conclusions that constitute variations in knowledge within the learners, thereby resulting in a product through which their diverging insights are intercommunicated to others.

The respective members of the team together in negotiation with the facilitator engage on how to develop a functional research question, the choice of theory as well as constructs and decide on the approach to be utilized and the subject for the analysis. To enable students or learners to consolidate their wider study competence, the initiated project work must be exemplary by utilizing methods, analytical and methodological comprehension as well as work with concepts and theories that go outside the given project. The aim is to help students to integrate their findings and the knowledge acquired in their previous experiences and utilize them in developing new experiences and skills as well as providing solutions to new problems.

Problem identification which is part of the learning process is among the responsibilities of learners in a POPOBL environment. This makes learners work and a team to make joint decisions to come up with ways of distributing and synchronizing work among the group members. The process enables learners to plan, initiate, and execute projects while at the same time develop their study abilities and competencies to manage a large amount of information that is within their reach and even beyond. To this effect, information literacy becomes a core requirement to enable them to locate information and materials as well as analyze its use for the construction of knowledge for their group. This is in agreement with the American Library Association [ALA], (1989), "To be literate in information, an individual should be able to discern when information is demanded and be able to locate, evaluate as well as effectively use the demanded information".

The teacher's role in POPBL changes from instructor to supervisor and facilitator with the responsibility of giving feedback for every consultation meeting from groups. The presentations and motivating questions asked by various group members determine the facilitator's advice and instruction. The teacher offers the needed advice as a facilitator based on his/her experience and relates it to the learners to help them appreciate the project with in-depth understanding.

4.1 POPBL Theories

Based on the scientific literature considered for this study, three theories were found most suitable to support the principle and process of POPBL. These include:

i. ***Experiential Learning Theory***: According to (Mcloone et al., 2014), experiential learning allows students to develop on their previous experience and interest. POPBL course applies constructivist and experiential learning approaches, thus, changing the learning process from passive or teacher-centred to active or students centred with students delivering while the facilitator receives and gives feedback (Wiek, Xiong, Brundiers, & van der Leeuw, 2014). Accordingly, students or learners are made to look into real-life position or problem and attempt various solutions to the given problem through teamwork commitment with the facilitators performing the role of coaches instead of teachers. The setting emphasizes on research and this delimits them from other types of experiential learning.

ii. ***Collaboration & Cooperative Learning Theory***: This is a learning environment where individual team members share learning experiences. The environment promotes students group learning, allowing them to utilize other's skill sets and resources as well as share knowledge and experiences that benefit the group (Theresa c., Wahsu, 2013). The theory builds on the fact that the learning process is facilitated when students learn a group with those with autonomous learning skills displaying more competitive attributes (Koç, 2005). According to (Zhou & Brown, 2015) the spirit of teamwork in collaborative and cooperative learning develops both academic and social personal skills of learners. This promotes higher levels of achievement, life-long learning, critical thinking, communication, cognitive skills, and cross-ethnic friendships. That knowledge is brought off as learners relate with each other and share experiences and ideas.

iii. ***The Constructivist Theory:*** This theory acknowledges thoughtfulness as a critical learning component as students develop their personal and corporative meaning. It is required that they consider it from all dimensions as the meaning takes form as well as consider it from a given distance as they prepare to proceed beyond their experiences that is their next learning challenge. Students can disclose things beyond their previously acquired experience and knowledge when they create time for conscious contemplation, their development as learners, and what (and how) they want to learn in projects ahead (Ibrahim & Abd.Halim, 2013)

a. POPBL Elements

The elements or components of POPBL which are extracted from PjBL and PbBL are in general identified as Problem, Teamwork, Project, Teacher's Role and Students' Role (Ibrahim & Abd. Halim, 2013; Ruhizan Muhammad Yasin, Mustapha, & Zaharim, 2009). These elements have the potentials of developing the generic skills that are much sought for in the 21st century and the4IR.

i. ***Problem:*** Problems performs the role of a catalyst and enables students to acquire skills and knowledge from their previously acquired knowledge and apply the information in later situations (Loyens, Kirschner, & Paas, 2011). This can be achieved by presenting information in a more liberal context to enhance better comprehension of the problem. What employers demand is the employee's ability proffer solution to a given problem within the expected time limit. According to (Audu, Kamin, Musta'Amal, & Saud, 2014), all employers source for the workforce that is amply equipped with the needed skills that go beyond ordinary reading, writing, and mathematics. They include critical thinking and problem solving since employers need employees who can work through problems by themselves or as effective group members.

ii. ***Project:*** The project-based learning approach was first introduced in Denmark for engineering technology programs together with PbBL for medical programs. This was aimed at boosting the entrance skills level of engineering graduates from universities Graaff and Kolmos, (2007) as cited in (Noordin, Nasir, ALI, & Nordin, 2011). Defining the features of a good project Adams (2013), noted that, a project must have realizable aims that lead to solving a problem; it must call for needs analysis; involve one or more results aimed at bringing the desired change; must have realizable aims based on the existing resources; must have a given time frame in terms of place and context; must be complex enough and involve the planning and implantation skills as well as performance players and partners; projects is a corporative task involving group participants that must work as a team; the project must be unique because every project is derived from new problems, challenges, and ideas; the project is a venture with various uncertainties and risk; project can be assessed by analysis and planning based on aims which must be subjected to evaluation.

iii. ***Teamwork***: Literature findings have revealed that teamwork determines the success of POBL (Danielsen & Lerche, 2010; Ibrahim & Halim, 2014; Lehmann et al., 2008; Mcloone et al., 2014). Mcloone et al. (2014), describes teamwork as someplace students "read, discuss, diagnose, and also check out ways to resolve the problem". To Herber, Deshmukh, Mitchell, & Allison (2016), POBL prompts learners to inter-communicate in the team to seek answers by veritable coaching circumstances. Active problem-solving teams are paramount qualities of POBL as team members frequently perform in a group to produce shared descriptions. Today, engineering production industries have come to realize what benefits and advantages that is possible through team-based jobs. The fact to be recognized by prospective engineers is that they are expected to work with personalities or maybe unfamiliar teams. Hence, they have to puzzle out how to adjust them to a new environment.

iv. ***Teacher's Role:*** The teacher's role in a POPBL environment changes from instructor to that of a facilitator. The teachers initially take an additional active role as a learner to learn the means of categorizing the learning things arising out of the "problems" and set goals and objectives. Progressively, the students are expected to develop professionalism through small assistance required. It is the responsibility of the teacher's to support the students understand the aspects of every subject, categorize learning means and collect information with an alternative procedure as well as stimulated students to be critical and vigorous in their learning (Mohd., Hassan, Jamaludin, & Harun, 2012; Ramachandran & Sedeeq, 2017). Besides, it is the duty of the teachers' to be educated on the learning needs of their students so that he/she can motivate learning and motivate the students' supports and efforts. Moreover, it will be the responsibility of the instructor to help students share responsibilities or duties accordingly for good interaction.

v. ***Students' Role:*** Students in a POPBL environment develop schemes on how to collect information, conduct the necessary research and later resume sharing and condensing the new knowledge acquired in the process. Student can arrive at a conclusion which can be or cannot necessarily be an output. Besides, they ideally require enough time for thinking and also make own assessment (Dole, Bloom, & Doss, 2016). The problem is usually the anchor of the POBL method and its success also counts on the problem, though the result could be from an optional viewpoint. Most POBL scheme purported for the students evidently indicate the problem, cultivate thoughts, gather information, and also talk to a specified outcome (Law & Chuah, 2004). Although efficient teachers evade the role of professionals, yet this could produce greater effects on students.

b. POPBL Process

POPBL procedures could be attained through the individual procedures of PbBL and PjBL. These include problem identification/analysis, applicable and alternative solutions,

ISSN 2229-5518

implementation and construction of the proposed components, and final testing of the project for quality assurance (Ibrahim & Halim, 2014; Mcloone et al., 2014; Ruhizan M. Yasin & Rahman, 2011). Ibrahim & Abd. Halim (2013), divided the process into three main stages: Problem analysis and design, Development & Testing, and Re-development (Evolution) & Testing.

i. ***Problem Orientation & Analysis:*** This stage of POPBL aims at reaching an ample serious comprehension of the given problem to ascertain that students are sure that their solution is adequate for addressing the problem. Understanding a given problem demands that you already know a setting that could be completely new for you - and acknowledging the imbalances in the setting. So to understand a situation, you have to study other agents and the people that view the situation troubling (Mcloone et al., 2014).
ii. ***Activation of Prior Knowledge:*** Once a given problem is examined and the root causes are discovered, the next phase is for the students to review their previous knowledge to determine their level of readiness to tackle the problem. This is carried out as soon as the essential thinking framework was actuated through direct recall, define, or even by manifesting to very important final knowledge or experience. Prior activation of knowledge can serve as a basis for newly acquired expertise on group members (Krauss & Boss, 2013; Rios & Montero, 2010; Tan & Chapman, 2016). According to Shekar (2014), the students' group focus on that knowledge supplied with fresh used knowledge which activates the previously acquired knowledge as well as relates the intellectual competence of the students.
iii. ***Research &Learning Objectives:*** Having activated the prior knowledge, students embark on further research to complement their previous knowledge. The objective of the given problem is now defined to guide the attainment of new skills and knowledge based on the set objectives. The objective clearly defines the quality and quantity of an attainable target's performance within the given time and resources (Harden, 2014). These objectives are not necessarily intended to be measured but instead, serve as a road map of the target result.
iv. ***Project Initiation and Execution:*** After conducting complementary research and the objectives spelt out, a project is initiated to achieve the set objectives. Project initiation and execution have no distinct process nor stages since various projects originate from different problems and have distinct objectives that define the steps to be taken (Akor, Subari, Jambari, Khair, & Onyilo, 2019). POPBL process of learning begins with the output result as the set goal and the team members follow a chosen procedure to arrive at the result or product.
v. ***Assessment/Evaluation:*** to ensure that the aims and objectives of a course are achieved, formative evaluation is carried out throughout the process. Since this aims at giving students concept understanding, they are expected to sustain it through experience instead of standardized tests. The nature of assessment here is open-ended and could be written and/or oral in group or individual. Another paramount measure utilized is a weekly reflective journal which applies a meta-cognitive approach. In this measure, students are sharing their learning process. In other words, they are carrying out self-evaluation on their learning process. Students' efforts, analytical skills, creativity/innovation, leadership, and teamwork are measured using portfolio assessment (Ruhizan M. Yasin & Rahman, 2011).
vi. ***Public Presentation:*** The presentation of the project to the public is a last and crucial stage of POPBL as the method aims at addressing the societal problems through the initiation and execution of the project. Presentation skills are very vital both within and outside the classroom (Loyens et al., 2011; Rathod & Kalbande, 2017) After the project has been completed, a public presentation is a platform for the team members to share with the audience what has been achieved. It also opportune students to challenge and expand on their knowledge of the topic by welcoming and responding to questions from others (Caesar et al., 2016). A confident presenter in the world of work can communicate, inform and motivate colleagues effectively. To get the students listening to each other, the audience can be set as a task with a set of questions being answered in a presentation (Pease & Kuhn, 2011).

c. POPBL Instructional Outcomes

Replacing the traditional large class with an integrated POPBL strategy encourages learners to actively participate in the study and accelerate their abilities of problem-solving, diagnosis, and logical reasoning(Wu & Chang, 2014). According to Latada & Kassim (2017), the "POPBL approach is in line with global recommendations to produce entrepreneurs that able to create employment opportunities for others". Additionally, as a problem is the mother of creativity, exposure to skills related to framing problem and problem-solving techniques should help our students to see the problem as an opportunity to excel. In a related development, Yasin & Rahman (2011), view POPBL as a systematic technique to develop students' effort, creativity & innovation, analytical skills, leadership, and teamwork.

Numerous studies have justifies that, POPBL implementation in coursework is helpful in terms of analysing and providing solutions towards the given real-world problems, managing and planning their project progress, and improving learners' experiences, knowledge, teamwork, leadership, life-long and continues learning, technology application, and creativity (Husin et al., 2016; Ibrahim & Abd.Halim, 2013; Wu & Chang, 2014; Ruhizan M. Yasin & Rahman, 2011).

5.0 POPBL and the 4IR Electronic Engineers

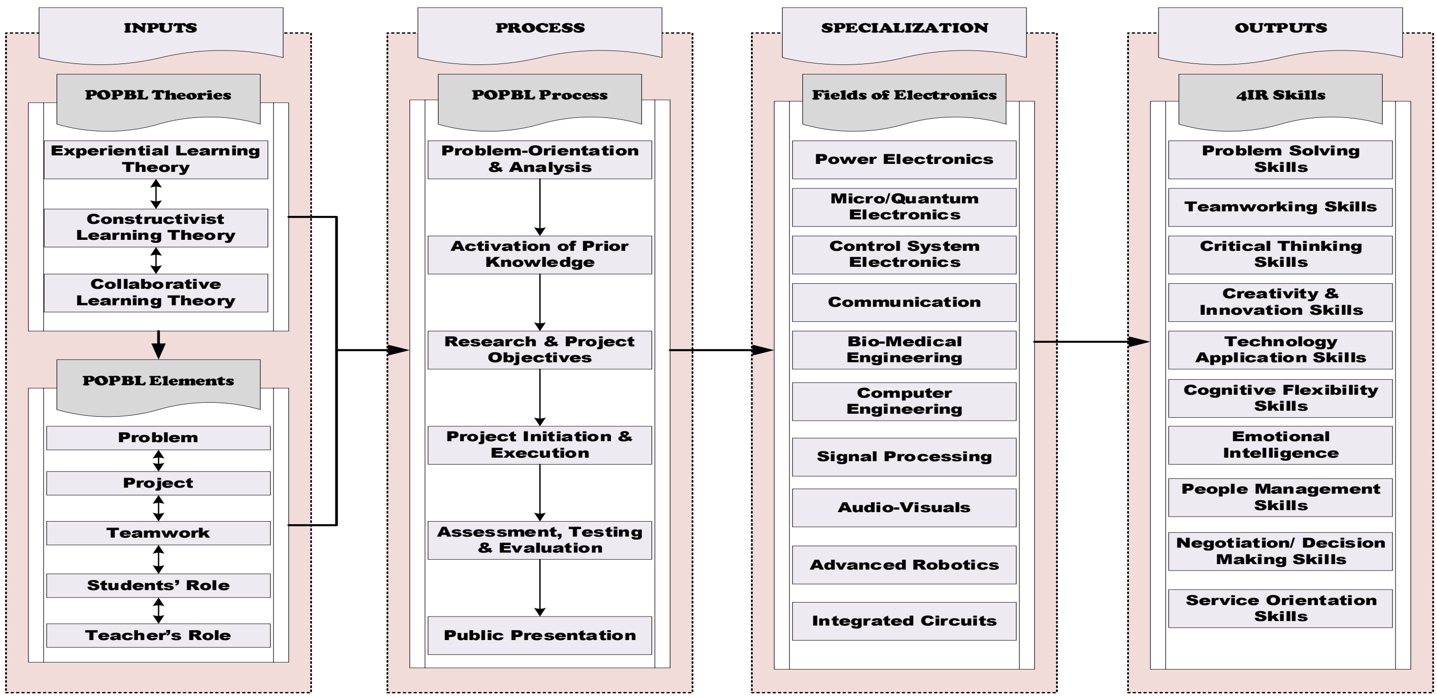
According to (Akor et al., 2019), POPBL integrated learning is based on five important, interrelated learning components, namely: problem, project, teamwork, teacher's role, and students' role. The resulting feature of this blend is students' centred, collaborative and self-directed learning, with real-world problem solutions as the primary focus. POPBL plays a complementary role by overlapping in important areas when applied in the teaching of electronics engineering. This helps engineers to adopt problem inquiry as in Problem-Based Learning (PbBL) to develop various optional solutions as well as product-orientation as in Project-Based Learning (PjBL). The implication being that, the blend eliminates the risk of endless problem analysis when only PbBL is used as well as jumping to solutions prematurely without sufficient enough problem analysis. Besides, the involvement of stakeholders in a collaborative process expands the engagement structure of the wider public of PbBL

The blend also enables students to solve a real word problem by applying knowledge through teamwork not regarding the instructors' timing of the syllabus. It has the potentials of exposing students' technical skills as well as non-technical skills such as cooperation, effective communication, critical thinking, creativity, project planning, and management. These skills are commensurate with the engineering skills needs of the 4IR which include complex problem solving, critical thinking, creativity, people management, coordinating with others, emotional intelligence, judgment and decision making, service orientation, negotiation, and cognitive flexibility. Creativity which is a core skill in POPBL, as well as the 4IR, will become a top skill to be demanded by engineers and the influx of new products, technologies, and working approaches will compare engineers to be more creative to benefit from the changes. With this, only engineers with robotic complementary skills will be found relevant in the industry and world of work (Akor, Subari, Jambari, & Khair, 2018). This entails that, developing these skills in electronic engineers who are the bedrock of almost all the driving forces of the 4IR will not only make them highly employable but also impact the 4IR positively.

6.0 POPBL Theoretical Framework

The theoretical framework for this study is developed based on the content analysis and synthesis of scientific literature on the 4IR, POPBL, and electronic engineering. The framework is an instructional algorithm that links the POPBL supporting theories, POPBL elements or components, POPBL process, POPBL learning outcomes, fields of electronics engineering, and the 4IR saleable skills as shown in Figure 1.

The POPBL framework is based on the constructivist, experiential and collaborative learning theories as well as the elements which include problem, project, teamwork, teacher's role, and students' role. All these serve as feeders to the process which begins from problem orientation/analysis thus: Activation of prior knowledge, research/setting of objectives, project initiation/execution, assessments/testing, and final public presentation. The process, when applied in the teaching and learning of various fields of electronics, leads to the development of the desired 4IR skills like critical thinking, problem-solving, teamwork, creativity, innovation, service orientation, negotiation, decision making, emotional intelligence, cognitive flexibility, and technology application.



7.0 Conclusion

This paper has presented and discussed a POPBL theoretical framework for the development of 4IR ready electronic engineers based on related scientific literature. The literature analysis revealed the characteristics, impact and the skills-need of 4IR and how electronic engineering is impacting on the revolution. Also revealed in the analysis is the potentials of POPBL to develop and impart the desired 4IR skills not only in electronics engineering but all aspects of engineering. Considering the effect of electronics engineering on all the driving forces of 4IR, it is expected that, integrating the POPBL theoretical framework in the teaching and learning of electronic engineering will not only boost the graduate employability but also lead to a positive development of the 4IR

References

Adams, S. (2013). What is a project ? In *Project Management Tool Kit* (pp. 27–38). Retrieved from http://youth-partnership-eu.coe.int/youth-partnership/documents/Publications/T_kits/3/2_project.pdf

Akor, T. S., Subari, K., Jambari, H., & Khair, M. (2018). Prospects of Problem and Project Based Learning Blend for Electronics Engineering Programmes in Nigerian Universities By. *The Turkish Online Journal of Design, Art and Communication - TOJDAC*, *Special Ed*(September), 1 – 17. https://doi.org/10.7456/1080SSE

Akor, T. S., Subari, K., Jambari, H., Khair, M., & Onyilo, I. R. (2019). Appreciating Green Radio Communication Network Systems in a Problem-Oriented Project-Based Learning Environment . A Theoretical Framework. *International Journal of Engineering and Advanced Technology (IJEAT)*, *8* (6), 864 – 874. https://doi.org/10.35940/ijeat.F8050.088619

Audu, R., Kamin, Y. Bin, Musta'Amal, A. H. Bin, & Saud, M. S. Bin. (2014). Assessment of the teaching methods that influence the acquisition of practical skills. *Asian Social Science*, *10* (21), 35 – 41. https://doi.org/10.5539/ass.v10n21p35

Baker, K. (2016). The digital revolution: The impact of the Fourth Industrial Revolution on employment and education. *EDGE: The Digital Revolution*.

Caesar, M. I. M., Jawawi, R., Matzin, R., Shahrill, M., Jaidin, J. H., & Mundia, L. (2016). The Benefits of Adopting a Problem-Based Learning Approach on Students' Learning Developments in Secondary Geography Lessons. *International Education Studies*, *9* (2), 51. https://doi.org/10.5539/ies.v9n2p51

Danielsen, O., & Lerche, J. (2010). Problem-oriented project studies – the role of the teacher as supervising / facilitating the study group in its learning processes. *Learning*, 558 – 565.

Dole, S. F., Bloom, L. A., & Doss, K. K. (2016). Rocket to Creativity: A Field Experience in Problem-Based and Project-Based Learning. *Global Education Review*, *3* (4), 19 – 32.

Gleason, N. W. (2018). Higher Education in the Era of the Fourth Industrial Revolution. *Higher Education in the Era of the Fourth Industrial Revolution*, 1 – 229. https://doi.org/10.1007/978-981-13-0194-0

Gray, A. (2016). The 10 skills you need to thrive in the Fourth Industrial Revolution. In *World Economic Forum, Davos.* Retrieved from https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Harden, R. M. (2014). *Learning outcomes and instructional objectives : is there a difference ?* (April 2002). https://doi.org/10.1080/0142159022020687

Herber, D., Deshmukh, A., Mitchell, M., & Allison, J. (2016). Project-Based Curriculum for Teaching Analytical Design to Freshman Engineering Students via Reconfigurable Trebuchets. *Education Sciences*, *6* (1), 7. https://doi.org/10.3390/educsci6010007

Hernandez, C., Ravn, O., & Valero, P. (2015). The Aalborg University PO-PBL Model from a Socio-cultural Learning Perspective. *Problem-Based Learning in Higher Education*, *3* (2), 16 – 36. https://doi.org/10.5278/ojs.jpblhe.v0i0.1206

Hirschi, A. (2018). The Fourth Industrial Revolution: Issues and Implications for Career Research and Practice. *Career Development Quarterly*, *66* (3), 192 – 204. https://doi.org/10.1002/cdq.12142

Husin, W. N. F. W., Arsad, N. M., Othman, O., Halim, L., Rasul, M. S., Osman, K., & Iksan, Z. (2016). Fostering students' 21st century skills through Project Oriented Problem Based Learning (POPBL) in integrated STEM education program. *Asia-Pacific Forum on Science Learning and Teaching*, *17* (1), 1 – 19.

Ibrahim, N., & Abd.Halim, S. (2013). Implementation of Project Oriented Problem Based Learning (POPBL) in Introduction to Programming Course. *International Research Symposium on Problem Based Learning (IRSPBL) 2013*. Retrieved from http://vbn.aau.dk/da/publications/pbl-across-cultures(5ce5393d-4200-46a8-bd65-fa47a304ea78).html

Ibrahim, N., & Halim, S. A. (2014). *Generic Framework Design of Project-Oriented Problem-Based Learning (POPBL) for Software Engineering Courses*. 359 – 364. https://doi.org/10.1109/MySec.2014.6986044

Koç, M. (2005). *Implications of Learning Theories for Effective Technology Integration and Pre-service Teacher Training : A Critical Literature Review*. *2* (1), 2 – 18.

KRAUSS, J., & BOSS, S. (2013). *Thinking Through PROJECT-BASED LEARNING Guiding Deeper Inquiry*. Retrieved from www.corwin.com

Latada, F., & Kassim, H. (2017). *Project-Oriented Problem - Based Learning (Popbl): an Initiative To Enrich Soft Skills Among Students At a Public University*. *1* (3), 75 – 83.

Law, K. M. Y., & Chuah, K. B. (2004). Project-based action learning as learning approach in learning organisation: the theory and framework. *Team Performance Management: An International Journal*, *10* (7/8), 178 – 186. https://doi.org/10.1108/13527590410569904

Lehmann, M., Christensen, P., Du, X., & Thrane, M. (2008). Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education. *European Journal of Engineering Education*, *33* (3), 283 – 295. https://doi.org/10.1080/03043790802088566

Loyens, S., Kirschner, P., & Paas, F. (2011). Problem-based learning. *APA Educational Psychology Handbook: Vol. 3. Application of Learning and Teaching*, 403 – 425.

Masek, A. & S. Y. (2017). *Problem Based Learning Model : A Collection from the Literature*. *6* (8), 148 – 156.

Maynard, A. D. (2015). Navigating the fourth industrial revolution. *Nature Nanotechnology*, *10*(12), 1005–1006. https://doi.org/10.1038/nnano.2015.286

Mcloone, S., Lawlor, B., & Meehan, A. (2014). On Project Oriented Problem Based Learning (POPBL) for a First Year Engineering Circuits Project. *ISSC 2014 / CIICT 2014, Limerick, June 26-27*. https://doi.org/10.1049/cp.2014.0719

Medrano, C. T., Ubé, M., Plaza, I., & Blesa, A. (2002). The tools of quality in electronic engineering education. *European Journal of Engineering Education*, *27* (4), 325 – 337. https://doi.org/10.1080/03043790210166639

Mohd., Y. K., Hassan, S. A. H. S., Jamaludin, M. Z., & Harun, N. F. (2012). Cooperative Problem-based Learning (CPBL): Framework for Integrating Cooperative Learning and Problem-based Learning. *Procedia - Social and Behavioral Sciences*, *56*(Ictlhe), 223 – 232. https://doi.org/10.1016/j.sbspro.2012.09.649

Naudé, W. (2017). *Entrepreneurship, Education and the Fourth Industrial Revolution in Africa*. Retrieved from www.iza.org

Noordin, M. K., Nasir, A. N. M., ALI, D. F., & Nordin, M. S. (2011). *Problem-Based Learning (PBL) and Project-Based Learning (PjBL) in engineering education : a comparison*.

Pease, M. A., & Kuhn, D. (2011). Experimental analysis of the effective components of problem-based learning. *Science Education*, *95* (1), 57 – 86. https://doi.org/10.1002/sce.20412

Ramachandran, M., & Sedeeq, R. (2017). *Learning Environment for Problem-based Learning in Teaching Software Components and Service-oriented Architecture*. *1* (Csedu), 249 – 255. https://doi.org/10.5220/0006257702490255

Rathod, S. S., & Kalbande, D. R. (2017). Improving Laboratory Experiences in Engineering Education. *Journal of Engineering Education Transformations, Special Issue, EISSN 2394-1707 2*.

Reis, R. M. (1997). *Preparing for Academic Careers in Science and Engineering Richard*. Stanford University IEEE Education Society, Sponsor The Institute of Electrical and Electronics Engineers, Inc., New York ©' WILEY- INTERSCIENCE A JOHN WILEY & SONS, INC., PUBLICATION.

Rios, I. D. L., & Montero, A. C. (2010). *Project – based learning in engineering higher education : two decades of teaching competences in real environments*. (December). https://doi.org/10.1016/j.sbspro.2010.03.202

Shekar, A. (2014). *Project based Learning in Engineering Design Education : Sharing Best Prac- tices Project-Based Learning in Engineering Design Education : Sharing Best Practices*.

Tan, J. C. L., & Chapman, A. (2016). *Project-Based Learning for Academically-Able Students*. Retrieved from https://www.sensepublishers.com/%0AAll

Theresa c., Wahsu, X. (2013). *Learning Theories*. Wikibooks.org.

Uziak, J. (2016). *A project-based learning approach in an engineering curriculum*. *18* (2), 119 – 123.

Wiek, A., Xiong, A., Brundiers, K., & van der Leeu w, S. (2014). Integrating problem- and project-based learning into sustainability programs. *International Journal of Sustainability in Higher Education*, *15* (4), 431 – 449. https://doi.org/10.1108/IJSHE-02-2013-0013

Wu, M. H., & Chang, C. C. (2014). The Research of Applied Project-Oriented and Problem-Based Learning Strategy on Wheel Robotics Study for Undergraduate Students: The S-P Table Analysis. *Applied Mechanics and Materials*, *536 – 537*, 1697 – 1704. https://doi.org/10.4028/www.scientific.net/amm.536-537.1697

Yasin, Ruhizan M., & Rahman, S. (2011). Problem Oriented Project Based Learning (POPBL) in promoting Education for Sustainable Development. *Procedia - Social and Behavioral Sciences*, *15*, 289 – 293. https://doi.org/10.1016/j.sbspro.2011.03.088

Yasin, Ruhizan Muhammad, Mustapha, R., & Zaharim, A. (2009). Promoting creativity through problem oriented project based learning in engineering education at Malaysian polytechnics: Issues and challenges. *Proceedings of the 8th WSEAS International Conference on Education and Educational Technology, EDU '09*, 253 – 258. Retrieved from http://www.scopus.com/inward/record.url?eid=2-s2.0-78149330649&partnerID=tZOtx3y1

Zhang, Z., Hansen, C. T., & Andersen, M. A. E. (2015). Teaching Power Electronics with a Design-Oriented, Project-Based Learning Method at the Technical University of Denmark. *Education, IEEE Transactions On*, *PP* (99), 1. https://doi.org/10.1109/TE.2015.2426674

Zhou, M., & Brown, D. (2015). *Educational Learning Theories*.