Appreciating Green Radio Communication Network Systems in a Problem-Oriented Project-Based Learning Environment. A Theoretical Framework

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Abstract*: *The aim of this article was to present a POPBL theoretical framework for the teaching, learning and research in Green Radio Communication Network Systems. To this effect, a content analysis and synthesis of related scientific literature, models and frameworks was carried out based on the research tittle and key words. The article analyses and syntheses centred on the importance of green radio communication, principal factors in green communication as well as the process components. Also in the content analysis and synthesis are the POPBL elements, processes and related theories with the resulting instructional benefits. The resulting framework has the potentials of developing the generic skills like problem solving, team work, creativity, critical thinking and continues learning which have the potentials of achieving the goals of GRCNS.

Index Terms*: *Problem-Oriented Project-Based Learning, Green Radio Communication Network System, Theoretical Framework

I. INTRODUCTION

The advent of Global System of Mobile Communication (GSM) has brought about high demand for dual-way mobile communication services across the globe. The total number of mobile users in the world now exceeds 4 billion with an average of over 4.6 million radio based stations globally. This increasing growth in the mobile communication industry has brought about increased demand for energy consumption with high carbon emission to the atmosphere. The current global power consumption by the information and communication technology (ICT) stands between 5% and 9% [1]. These development calls for drastic transformation of energy system to decentralized energy exchanges or customer management as against the existing smart networks. The system currently contributes over 4% emission of CO_2 in the atmosphere. It has been predicted that, while the ICT footprint is likely to increase by less than 100%, the mobile communication is likely to triple within the between 2007 and 2020 [2]. Considering the existing trend, the need for an improved energy efficiency in mobile communication systems has become urgent as can be seen in the aggressive efforts by many nations to curtail the greenhouse gasses (GHGs) through reduced energy consumption.

The society now faces numerous energy related challenges like energy shortage, tariff hikes, and global warming with consequent effects on the environment, health as well as socio-economics well-being [3], [4]. With the existing mobile communication's architecture that is less energy efficient, there is a growing public call for green concepts like green radio communication networks (GRCN) which is attracting much interest in the industry and university research. This call for a systematic and logical instructional approach in the teaching and learning of GRCN system hence Problem-Oriented Project-Based Learning (POPBL), which is a hybrid of Problem-Based Learning (PbBL) and Project-Based Learning (PjBL) [5]. This article is a content review of related works on GRCN development process and how best, POPBL could be utilized in developing generic skills in the in GRCN.

II. GREEN RADIO COMMUNICATIONS NETWORK SYSTEMS (GRCNS)

As earlier stated in the introduction, the ICT industry sector accounts for global energy consumption of about 5-9% with a significant percentage being consumed by mobile and wireless communication industry. In addition, there is an unprecedented growth in wireless technology due wireless data applications' proliferation with resultant rise in the number of installed based station and higher grid power demand thus, increasing global carbon footprint [6], [7]. There is an urgent demand for wireless communication industry to embrace eco-friendly green communication technologies at various levels ranging from circuits, components, systems, networks and devices protocols.

As a result of high data traffic growth which outpaces the hardware devices' power efficiency, there is high tendency that network scaling will strongly depend on future wireless protocols' energy consumption as well as systems and networks. This calls for the development of

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green wireless system technologies and networks that can improve energy efficiency as well as reduce GHGs emission [1], [8]. These green radio technologies will help in the cost reduction of operating wireless networks.

Research in green radio is a wide and comprehensive area that covers every aspect of efficient wireless communication network design. A lot of effort have been devoted to the conventional ways of saving energy such as the design of ultra-efficient power amplifiers, feeder losses reduction, and the introduction of passive cooling systems. These efforts are however, isolated and as such, are unable to meet the global vision for the achievements energy saving for at least a decade. The innovative efforts aimed at solving these problem is not an individual or isolated affair but needs a teamwork to achieve the dream.

According to [3], [9], next generation networks is threaten by the provision of efficient energy solutions for the transmission of data with variety of Quality of Service (QoS) requirements as well as tolerance of less than optimum services. Applications likely to be transmitted across Next Generation Networks (NGNs) include:

i. The ones with real time inter-connected requirements and capacity to contain slight losses
ii. The ones with real time inter-connected requirements and capacity to cope with losses
iii. The ones without real-time requirements but unable to cope with loss
iv. The ones without real-time requirements and capacity to contain with slight losses

Energy effective capabilities of communication are consequently, expected to support the various QoS requirements. Additionally, the NGNs make use of carrier type to enable the applications of diverse ranges, with several technologies in transverse towards intermediate destination and source. For instance, transmission between endpoints of communication may travel between nodes connected with wired links in network core or data center, if not across wireless links to a mobile device [10]. There is also need for QoS to be supported in as well as redefined for environments with various levels of capabilities to enable the application requirements.

The NGNs attributes move the path of power effective network solutions where there is autonomous occurrence of network intelligence in response to real-time dynamics. There must be context collection to obtain energy efficient procedure, as well as maintain appropriate decisions on each variety of network and in consonance to nature and transmission needs being sent. Next generation green network solutions, consequently, need to take into account, the qualities of client devices, applications and networks, the possible configurations for each service level normally achieved across each portion of network, and the capacity to enable application of QoS needs to optimize the operation's effectiveness.

A. The Need for Energy Efficient Networks

Energy efficiency techniques are consequently being created for wearing in next generation networks, and power restrictions as well as productivity goals of telecommunication operation influence the control techniques deployed. When power-saving is actually used in a notebook computer, for instance, the display screen backlight dims as a part of a battery conservation method. When energy saving is actually used in a wireless sensor network, on the additional hand, an intermediary node might have the performance to' shut-down' to ensure that just minimal probe packets are distributed to figure out the need of its to' awaken' as well as become fully or partially useful [6], [11]. A choice of domains, for which energy efficiency is actually a limiting pressure on operational ability (e.g., delay tolerant networks), from which environmental issues with the volume of emissions arise (e.g., data centers) and for which intelligent energy management is important (e.g., mobile devices) are considered by the authors in the provision of environmentally friendly media strategies. In the situation of smart homes, for instance, intelligent energy management is starting to be vital as a result of the motivation for' always-available' range as well as services of products which might be networked making use of the Internet Protocol. The QoS attainable will be higher when products are made in an on-demand fashion; as a result, users might, therefore, be much more likely to keep products driven on (at a minimum in standby mode) and disable power options that are lower choices for convenience, showing a chance for autonomous and intelligent management of products to improve efficiency [12], [13]. In a data center, on the other hand, environmental issues arise due to the volume of devices in plants which are ready to service customer requests as well as the associated plant management costs (including lighting as well as air conditioning) incurred while keeping a good operating environment. Energy efficient media is likewise essential in outlying farming regions; wireless fixes are more quickly deployed and less expensive to roll out in these areas. Effective utilization of wireless resources can help to maximize the network's lifetime and operational ability, farmer energy gotten from the network as well as satisfaction with services offered.

B. Goals of Green Networking

Across the assortment of domains, goals of environmentally friendly network interaction as well as control strategies include:

i. Reducing the carbon footprint of Communication networks
ii. Enhancing operating sustainability in remote networks
iii. Reduce the monetary price for transmit by operators
iv. Allowing software QoS to be attained within network source constraints
v. Reducing network load and hence per transaction energy consumption
vi. Bridging the digital barrier between rural and urban areas; and
vii. Contributing to manufacturing standards.

Irrespective of having enhanced sustainability, the general necessity of environmentally friendly IT across domains is decreasing the amount of bits a transmission so that energy requirements are curtailed, power price lowered and carbon emissions lowered [3], [12]. Energy effectiveness goals from this point of view, consequently, consists of the reduction of energy usage in wired networks, and also in wireless networks comes with maximization of operational sustainability. According to [4], [9],the contrasting needs of

effectiveness in two exemplary domains, the information center as well as wireless sensor network, are actually compared: in wireless sensor networks, node power resources are actually constrained: Goals of that situation, consequently, prioritize sustainability to maximize the network's operational lifetime. In data center networks, on the other hand, there's a high level of redundancy to minimize response time as well as maximize overall performance when responding to client requests. Minimizing energy usage in this particular planet is, therefore, a primary goal of NGNs tools. Sustainability as well as price reduction specifications are approached with equal value of the development of environmentally friendly media strategies, both a consequence of the more effective operation [8], [10]. In enhancing the effectiveness with which communications happen, price per transmission will go down and sustainability enhanced.

III. POPBL ENVIRONMENT

Problem Oriented project-based Learning (POPBL) aims at obtaining solutions to societal problems as well as promoting learners creativity. The experience promotes learners' knowledge acquisition from the findings and discoveries [14], [15]. This approach is learners' centered and does not require memorization of theories or formulas but promotes the acquisition of analytical and creative thinking through information analysis obtained to solve the problem [16], [17]. POPBL is process centered rather than content and as such, focuses on orienting the curriculum content around the problem scenario instead of subject or courses [18], [19]. In this process, learners are engaged with complex settings as well as the information and skills needed in managing the situation[20], [21]

According to Danielsen & Lerche, (2010), POPBL is qualified by cooperative groups' project work, and active participation learning, participatory guided in a negotiation between students and the teacher as a supervisor and facilitator [22]. Furthermore, it is cross-disciplinary in knowledge acquisition from various academic fields. The starting point for a POPBL is the investigation stage where learning groups investigate a problem which they do not know and this provokes their thoughts for action [20], [23], [24]. In the cause of trying to solve the given problem, groups embark of organized dialogue process by collecting relevant materials and data; use relevant theories and methods as guides to logically transform and organize the materials or data to identify and clarify the problem area as well as research questions. This is followed by drawing conclusions that represent various differences in knowledge among the learners, thereby arriving at a product through which their divergent insights are communicated to others.

The various groups' members together in dialogue with the supervisors discuss how to formulate an operative research question, the theory choice as well as concepts and decide on the method to be applied and the field for the analysis. In order to help learners consolidate their broader study competence, the project work has to be exemplary by applying methods, analytical and methodological understanding as well as work with theories and concepts that go beyond the given project. The aim is to enable learners to incorporate their findings and the knowledge gained in the previous experiences and apply them in constructing new variable skills and experiences as well as solutions to new problems.

Identifying a problem is one of the learners' responsibilities in POPBL as it is in itself a large part of the learning process. This entails learners working jointly in taking joint decisions to figure out how to share and synchronize work among them. Through this processes, learners learn how to plan, manage and evaluate projects. They are also developing their study competence and abilities to handle a large amount of information which must be within their reach through the library, database and the internet. As a requirement, learners must be information literate to enable them to find and locate data and information as well as judge and evaluate its use for knowledge construction of their group. This agrees 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".

This process views knowledge as resulting from cooperation and collaborative actions where learners bring relevant information based on previous experiences and knowledge. From this view, learning is not considered as taking place exclusively in the mind of an individual away from work-related contexts and practice. Learning is understood as situational, contextual and dynamic, and it takes place through active involvement in social interactions and practice with others.

In POPBL, the teacher's role shift from teaching to supervision and facilitation. The supervisor's role in this method is to give feedback for each consultation meeting from the groups. He/she advises the groups based on their various presentations and asks motivating questions. As a facilitator, the teacher offers the necessary attention to the groups, offers his/her own experience, relates to the learners and helps them to gain an in-depth understanding of their project work. The facilitator in this setup is expected to be flexible and sensitive to the learners' needs with the responsibilities of acting as an expert on the specific subject; focusing on processes and methods, and actively listening to the psychological dimensions that take place among group members.

IV. METHODOLOGY

This article aimed at developing a theoretical framework on appreciating green radio communication network systems through using POPBL environment. To this effect, a content analysis and synthesis of scientific literature was carried out in related studies on Green Radio Systems, Green Communication Networks, POPBL, and POPBL. The content analysis and synthesis centered technical the need, objectives and components of green communication, elements and process of POPBL.

The resulting theoretical framework for appreciating green radio communication systems was based on technical roadmap for green radio communication with consideration to green design components and factors, POPBL process and the related generic skills. The framework linked the green communication technical roadmap block with the relevant POPBL stages and the associated generic skills.

To address this, the following questions were

considered in reviewing scientific literature for the development of a POPBL theoretical framework on generic skills in green radio communication system:

i. What are the key principles to be considered in the teaching and design of green radio communication systems?
ii. What are the core components to be considered in the teaching and design of green radio communication systems?
iii. What is the POPBL components, processes and related theories to be considered in the learning and research in green radio communication network systems?
iv. How could the GRCNS' principles and components as well as the POPBL components, processes and theories be utilized to arrive at theoretical framework for the teaching of GRCNS?

The core aim is to provide a roadmap for educators and researcher on how to logically and systematically understand green radio communication system as well as the development of future innovative ideas in the area.

V. RESULTS & FINDINGS

To answer the above research questions, a logical content review of scientific literature was carried out based on the aims of the research. A content review was carried with a focus on problem-based learning (PbBL), project-based learning (PjBL), problem-oriented project-based learning (POPBL), green communication network systems (GCNS) and green radio communication network systems (GRCNS). The findings are as shown in the following sections

A. Green Radio Communication Design Principles

The Design Principles of Sustainable Communication are as follows:

Nature

i. ***Design learning from nature:*** consider nature as a source of inspiration, instead of exploitation. Learn recognizing patterns, processes, models and systems as well as discover unlikely connections.
ii. ***Design to keep the systems alive:*** any action is taken must be part of interconnected and complex system with such attempts and connections to foresee consequences, such as maintaining drinking water, breathable air and living forests. People must be considered, also as systems of needs, results and actions.
iii. ***Design associating the outcomes with nature:*** choice of materials, processes, and open cycles for reabsorption of the matter must be made without any compromise to its quality, or the environmental quality. Report fruitful outcomes, for example the amount of saved resource and how this assists to constitute a direct connection between the developments that were done and the level of nature which has been preserved.
iv. ***Design within the limits* of *nature***: for nature to survive, its limits must be respected through the acknowledgement of the limits of resources, time, or systems' regeneration.

Culture

v. ***Design with values:*** sociologists and anthropologists are continuously acknowledging the importance of a cultural dimension in our lives. Values are fundamental in defining our personal individuality as well as cultural values, that play a vital role in enhancing our believes of belonging to the community. Values must be defined and reflected in our works
vi. ***Design for peoples' cardinal values:*** it is obvious that the so-called "free market" has failed to measure with its single metric scale, concepts such as identity, values, community belonging or cultural values thus, making it impossible to quantify its relevance. This view can be changed through designs grounded in human cardinal values.
vii. ***Design encompassing diversity in culture:*** the widespread ideology that limits development of one pattern without considerations to the other relevant approach is unacceptable. The diversity of approaches is per se linked to cultural diversity thus, calling for respect and utilization of other cultural approaches.
viii. ***Design for an in-depth sense of fulfilment:*** as the saying goes "being is more important than having and seeming". Designers are expected to provide solutions that foster in-depth sense of fulfilment, intellectual, mental, sensory, and experimental with less material as possible.

People

ix. ***Design to inspire change:*** designers are expected to contribute to cardinal advancement in human well-being as well as developing solutions that lead to a more sustainable future. Designers can be factors of change, and also prompt change among equals and community.
x. ***Design to foster sustainable behaviour:*** designers can encourage a more sustainable conduct, justifying specific actions or options a shift in behaviour that leads to sustainability.
xi. ***Design regarding human rights*:** ensuring respect for the human rights and fair working conditions and level playing ground to all. Respect human diverseness and inclusiveness.
xii. ***Design sharing knowledge:*** share your acquired knowledge and experiences among the community and peers.

Economy

xiii. ***Design investing in your expertise*:** considering the complexity of sustainability era with its constant evolution, designers are expected to develop their skills and improve their knowledge
xiv. ***Design unveiling new opportunities:*** in any sector, being it primary, secondary or tertiary, there abound untapped opportunities yet to be discovered. For instance, the tertiary sector

which is free from market conditioning rules has the capacity to offer new challenges encouraging the development of new innovations

xv. ***Design saving resources:*** whenever possible, designers are expected to proffer solutions to problems that do not require production of physical product, but rather take advantage from the existing multifunctional platforms.

xvi. ***Design for value not for profit*** Much considering should be given to value rather than profit to ensure that the aims of green communication are achieved without resulting harm to the society.

B. GRCNS Design Components

The core components of GRCNS are: energy efficiency metrics which deals with energy consumption at the Base Stations (BSs) at the components level; effective minimization of BSs energy consumption in power amplifiers, designing power saving protocols, implementing cooperative BS power management, using renewable energy resources and bringing some simple architectural changes; network planning energy efficiency; system design with emphasis on cognitive radio and cooperative relays; different perspective on future wireless systems.

Measuring Greenness (The Metrics): Prior to making any design decision on green networks, consideration must be made to the meaning of "green" and how to measure "greenness" in communication networks. Also to be put into consideration are green technology motivating factors like economy in terms of lower costs and practical usage with respect to increased battery life of mobile devices. The matrices provides information on how to compare and assess the consumption of energy in various components as well as the entire network. They also help for the setting of long term research goals on energy consumption reduction. This is eminent in the increased research activities on green communications and hence in a number of diverse power efficiency metrics, standards organizations such as European Technical Standards Institute (ETSI) and Alliance for Telecommunications Industry Solutions (ATIS) are currently making efforts to define energy efficiency metrics for wireless networks

Architecture (Energy Savings in Base Stations): The number of worldwide cellular BSs has increased from a few hundred thousand to many millions due to the rapidly growing demand for mobile communication technology, within a last couple of years. This hick in number BSs accounts for simultaneous jump in green house emission as well as high energy cost of operation. There is a reported power consumption of up to 1,400 watts with corresponding annual energy cost per BS of $3,200 with carbon foot print of 11 tons of CO_2 [13]. To this effect, BSs designers and manufacturers are encouraged to offer a various eco and cost effective solutions to minimize energy demands of BSs as well as support off-grid BSs with resources of renewable energy. As the number of BSs increases, it becomes crucial to address their energy consumption for a cellular network.

Network Planning (Heterogeneous Network Deployment): The exponential growth of need for higher information rates along with other providers in wireless networks calls for a far more thick deployment of base stations within network cells. Whereas traditional macro cellular network deployments are much less efficient, it might not be economically feasible to alter the present community architectures [3], [11]. Microcells are usually designed to offer huge coverage and aren't effective in offering huge data rates. One clear way to create cellular networks far more power effective in order to experience higher velocity data-traffic is actually by lessening the propagation distance between nodes, hence cutting back on the transmission power. Thus, cellular networking deployment treatments based on smaller sized cells like micro, pico & femtocells are promising in this particular context. One benefit of smaller cells is actually that they may make use of increased frequency bands ideal to supply higher data rates and in addition provide localization of radio transmissions. Nevertheless, deploying very many smaller cells inside a macro cell could decrease the general effectiveness of the macro cell BS, because it is going to have to operate within low load circumstances. Therefore, a thorough investigation of various deployment methods need be carried out to discover the way to best deploy some smaller cells.

Enabling Technologies (Cognitive Radio and Cooperative Relaying): Lately, the study on technologies like cognitive stereo and cooperative relaying have gotten a major interest by each academia and business. While cognitive radio is intelligent as well as adaptive wireless communication which allows us to use the radio spectrum a method more effective manner, cooperative relays could offer a great deal of enhancement in coverage as well as throughput for futuristic wireless networks [4], [13]. Nevertheless, advancements in both these technologies moreover, allow us to resolve the issue of energy efficiency through intelligent radio transmission and distributed signal processing.

Design (Addressing Energy Efficiency In Future Generation Wireless Systems): With this section, we'll mainly discuss methods to allow greener reception in the future generation of wireless devices which will depend on cooperation and cognition to meet the growing need for higher data rates. And so much, achieving huge details fee continues to be the primary focus of investigation in cognitive and cooperative radio systems, with no much consideration of energy efficiency [13]. However, a number of these methods greatly improve method complexity as well as power usage. For example, in the context of environmentally friendly correspondence through cognitive radio, writers mention that you will find two essential but entangled aspects: how you can make use of cognitive stereo for energy efficiency purposes, and how you can create the cognitive radio work in an energy efficient fashion. Escalating electricity costs and environmental worries have produced an immediate need for more energy-efficient "green" wireless communication [2], [8]. Hence, we have to be assertive in developing energy efficient ways for cooperative and also cognitive networks that will likely operate the upcoming generation of wireless communication. As an example, in case cooperative and cognitive methods are anticipated to provide 50 % of energy savings, then an extra 50 % improvement in the energy efficiency of the methods will additionally up the web savings by 25 %.

Some Broader Perspectives: The most crucial issue in creating networks which are actually energy aware is

actually modelling the usage of the wireless interfaces. Generally, the wireless screen consumes power that has the same price of receive, transmit or perhaps idle states. In turn, the less the wireless screen is actually operating, a lesser amount of power is actually consumed. According to the preceding argument, the best technique to lessen the power use is to shut down the wireless screen, or even to go to energy saving mode almost as practical [13]. To accomplish this, algorithms required to determine when it's ideal to shift to energy saving mode or even switching off the transceivers. We currently have discussed methods with the aforementioned idea in this particular paper. For example, we've pointed out Discontinuous Reception (DRX) and Discontinuous Transmission (DTX) modes in LTE standard, and sleep mode mechanism both for movable terminals [4], [11]. We likewise have discussed enabling sleep mode for BSs. Nevertheless, these techniques are based on instantaneous observations. On the other hand, the traffic pattern is considerably different at various times during the day or perhaps in various geographical places. In a broader perspective, there could be a database in BS along with mobile terminals, in which the traffic pattern throughout various times during the day is actually preserved. Based on this obtained statistics, powerful algorithms could be designed to be able to turn movable terminal or the BS to an alternative energy profile suitable for that time of the day.

C. POPBL Related Theories, Elements & Process

POPBL Related Theories

Various theories were considered based on the supporting literature of POPBL principles and processes. They include:

i. ***Experiential Learning Theory***: According to [23], in experiential learning, students are expected to develop on their interests and previous experience. POPBL course utilizes constructivist as well as experiential approaches of learning, thus, shifting learning from passive or teacher cantered to active or students centred where students deliver, instructor receives and gives feedback [25]. Accordingly, students are made to investigate real-life situation or problem and try various solutions to the problem through small groups' engagement with the instructors acting as coachers instead of teachers. In this setting, emphasis are laid on research and this demarcates them from other forms of experiential learning [26].

ii. ***Collaboration & Cooperative Learning Theory:*** Which is a learning environment that group of individuals who try to share learning experiences. The environment enables students to learn together and from each other, makes use of other's resources and skills sets as well as share experiences and knowledge that benefit the group [27]. The theory is based on the fact that, learners are more likely to succeed when they learn in group setting and cooperation, while those that learn autonomously are more capable of displaying competitive attributes [28]. According to [29], the spirit of teamwork in cooperative and collaborative learning builds both academic as well as social personal of learners. This enhances higher achievement levels, life-long learning, cross-ethnic friendships, communication, critical thinking, and cognitive skills. That is, knowledge is negotiated as learners interact with each other and share ideas and experiences.

In terms of theory, [20] observed that, the understanding of POBL takes it point of departure in the constructivist- sociocultural approach of understanding learning and education. Within theories of constructivism, learning is understood to be an ongoing and developmental process of active meaning-making undertaken by the learner. Learning is thought to involve a process of building meaning systematically as new knowledge combines with old in a process of restructuring.[30]

iii. ***The Constructivist Theory***: This theory acknowledges reflection as a vital learning element as students create their individual and collective meaning. It is expected that they view it from all ends as the meaning takes shape as well as view it from a give distance while preparing to step beyond their experiences which is their next learning challenge. Students are able to reveal things beyond their previous knowledge and experience when they set aside time for conscious reflection (and what they enjoyed about learning), their growth as learners, and what (and how) they want to learn in projects ahead.[31]

POPBL Elements

The key elements of POPBL have been defined by various authors and authorities with each having its peculiarities. These elements or components which are derived from PjBL and PbBL are generally identified as Problem, Project and Teamwork [16], [32]–[34]. Since this study aims at teaching and learning, the researcher adopts problem, project, teamwork, teachers' role and students' role as the core elements for the POPBL model. These elements are capable of influencing the generic skills which much sought for in the present century and the 4th Industrial Revolution.

i. ***Problem:*** Problems act as encouragement to students and enables them to acquire knowledge and skills from their previous knowledge in order be able to apply the information in subsequent situations [35]. This can be accomplished by presenting information in a broader context to enhance better understanding of the problem. What employers need is the employee's ability provide solution to a lingering problem within a reasonable time frame. According to [36], all

employers seek for the workforce that is fully equipped with the requisite skills that go beyond ordinary writing, reading and mathematics. These include problem solving and critical thinking.

Employers need employees who could work through problems by themselves or as a good member of a group. Perfect personnel are able to think creatively and critically, share views as well as opinions, utilize good judgment, and also make choices [37]. As a brand new employee, you might question why a company follows particular steps to complete a job. It might appear to you that among the actions, one might be removed saving time, money, and effort. Though you may be reluctant to voice your opinion. Do not be employers are generally appreciative when new workers are able to provide insight and a new perspective in better plus more effective methods of doing things. It's essential to remember, nonetheless, which as somebody new to the business, you might not necessarily get the whole photo, and therefore there might be aspects you're ignorant of which dictate that things be accomplished in a specific manner. Another essential thing to keep in mind is that when you're tasked with solving an issue, you do not always need to answer instantly.

ii. Project: Project learning approach was introduced in Denmark for engineering programs alongside with PbBL for medical programs. This was to boost the entry skills level of engineering graduates from universities Graaff and Kolmos, (2007) as cited in [38]. Defining the characteristics of a good project [39], noted that, a project must have clear aims and objectives which is mostly aimed at solving a problem; it must involve needs analysis; involve one or more solutions aimed at bringing lasting change; must have achievable aims based on the available resources; must have a time frame in terms of place and context; must be complex enough and involve skills planning and implementation as well as execution players and partners; projects is a collective task involving a team of various participants who must work collaboratively; project are unique as every project is termed from new problems, challenges, and ideas; project is an adventure with various risk and uncertainty; project can be assessed by planning and analyses bases on aims which must be subjected to evaluation

iii. Teamwork: Literature findings have revealed that, the success of POBL depends on teamwork [16], [20], [22], [23], [32], [40], [41]. [24], describes teamwork as someplace students “read, discuss, diagnose, and also check out ways to resolve the problem". [42], claim that POBL motivates learners to communicate in the team to find answers by authentic coaching circumstances. Active problem solving teams are important qualities of POBL. In POBL teams, members frequently perform in a team to create shared descriptions. Most POBL teams necessary approximate support to interact effectively. Inside an old style of POBL design and a mentor supports to ensure that students are engaged in the conversation.

Today, engineering industries have rapidly come to realize what advantages and benefits that are acquired through team based jobs. Moreover, tasks grounded on teams are in a position to boost business revenues coming from the brand new evolved programs [43]. Students of Engineering are often doing the jobs and creating a group out of the individuals they close ranks and properly realized the aims. It is obvious that the success of a task is determined by how healthy we can cooperate and meet up with others in a team so long as everybody is giving their full effort and participation [40]. Nevertheless, the fact that has to be recognized by potential engineers is the fact that they are going to work with individuals or maybe a team people that they are not familiar with. Hence, they have to figure out how to adjust themselves to an environment that is new.

iv. Teacher’s Role: The instructor performs a tremendous part in shaping the problem solving and self-directed learning competencies necessary for self-evaluation group members’ consideration and thinking. Though the instructor reduces the magnitude of support to the students, as they acquire information with the POBL method, he/she remains as an observer, building from time-to-time resolutions on exactly how great to help the POBL process. He/she design the self-directed and problem-solving learning procedures. Additionally, the teacher supports pupils acquire to interact efficiently. An essential hypothesis is when teachers scaffold the understanding and interaction methods, pupils should be effective at creating a twistable understanding.

In POBL tutorials, a teacher works with a group of Learners to help in the learning process. Instructors are acquainted with the typical and also the accurate mastering goals of the book. Initially, the teachers take an additional lively role as students to learn the means of classifying the learning things originating out of the "problems" and fixed goals and objectives. Steadily the pupils are anticipated to develop professionalism via small assistance required. It is the teacher’s responsibility to support the students comprehend the functions of every subject, classify learning means and collect info with an alternative procedure as well as stimulated pupils being critical and vigorous in their learning [36], [44]. Additionally, it's the teachers' duty to be educated on the learning needs of the

students of theirs so that he is able to motivate learning and encourage the students' supports and exertions. Moreover, it will be the duty of the instructor to help learners share responsibilities appropriately for good interaction much better than unite. Additionally, they express that a subject mentor functions thoroughly with the POBL groups and also observes the actions as well as outcomes created through the technique.

v. ***Students' Role***: In a POPBL environment, students develop strategies on how to collect info, conducted the necessary study and later resume sharing and condense the acquired new information in the team. Student are able to draw a conclusion which can be or cannot be an output. Additionally, they ideally require enough time for thinking and also make own assessment [45]. Problem is usually the backbone of the POBL method and its success depends also depends on the problem, though the solution could be from an alternative viewpoint. Most POBL strategies proposed for the students obviously indicate the problem, cultivate thoughts, collect information, and also talk to a clearly specified outcome [46]. A lot of problems in POBL are produced as learning embedded conditions for the objective of involving the students in learning as well as information searching but not discovering a means to fix the difficulty as by so doing the students will produce a lot of skills that are essential for their future use. Some students in their thinking for the long period considered their teacher as a reservoir of knowledge. Based on that enlightenment concerning proficiency of their course content and their conventional retrieval of evidence prerequisite of students, various students seem to be missing the capability to "just wonder about something" [47]. Though students normally favour POBL teaching and the capability in solving authentic problems through projects, it seems improving against the teacher-centred approach, certain matters need to be considered before the commencement of POBL approach in teaching and learning. Although efficient teachers evade the role of professional, yet this could produce greater effects on students.

POPBL Process

POPBL processes could be arrived at through the individual processes of PbBL and PjBL. These include: problem analysis, applicable and alternative solutions, implementation and construction of the proposed components, and final testing of the project for quality assurance [16], [23], [24], [33], [48]. [32], divided the process into three main stages: Problem analysis and design, Development & Testing, and Re-development (Evolution) & Testing.

i. ***Problem Orientation & Analysis:*** The main aim of this stage of POPBL is reaching a sufficiently serious understanding of the given problem to ensure that students are confident that their solution is capable of addressing the problem. Understanding a given problem requires you already know a scenario which could be entirely new for you - and knowing the imbalances in scenario - while making certain you have completed everything possible to avoid biases arising from your own personal situation to interfere. Situations are tricky just for individuals - nature does not have some "problems." So to know a situation, you have to learn other agents and the people that find the situation troubling.

ii. ***Activation of Prior Knowledge:*** Once the problem is analysed and the root causes are identified, the next stage is for the students to review their aptitude to ascertain their level of preparedness to confront the problem. This is don as soon as the crucial thinking framework of the students was activated through directed remembrance, define, or even by demonstrating to very important last experience or knowledge. Prior knowledge activation can serve as a foundation for newly acquired expertise on group members [49]–[51]. Whether the students have the requisite knowledge or not, learning might be exclusively aided when the coaching provides crucial awareness that might be used as a starting on the impending encounter [52]. Having the students share their key experience between them is a good method to supply this stimulation of expertise. Linking the data by the students leads to the activation of the previously discovered program. According to [53], the grouped students focus on that knowledge provided with fresh second-hand knowledge which promotes the previously acquired knowledge as well as relate the intellectual competence of the students.

iii. ***Learning Objectives:*** After the activation of the prior knowledge, the objective of the problem are now outlined to guide the acquisition of new knowledge and skills based on the objectives. Objectives refers to a manageable commitment to achieve specified outcomes within a given period. They clearly outline the quality and quantity of an achievable target's performance within the given time and resources [54]. Due to the student-centred nature of POPBL, the entire procedure is the focus without emphasising the predetermined behaviour as POPBL emphasizes the achievement of measurable learning outcomes which form an integral part of the problem [49]. It is the learning objectives which can identify the expected

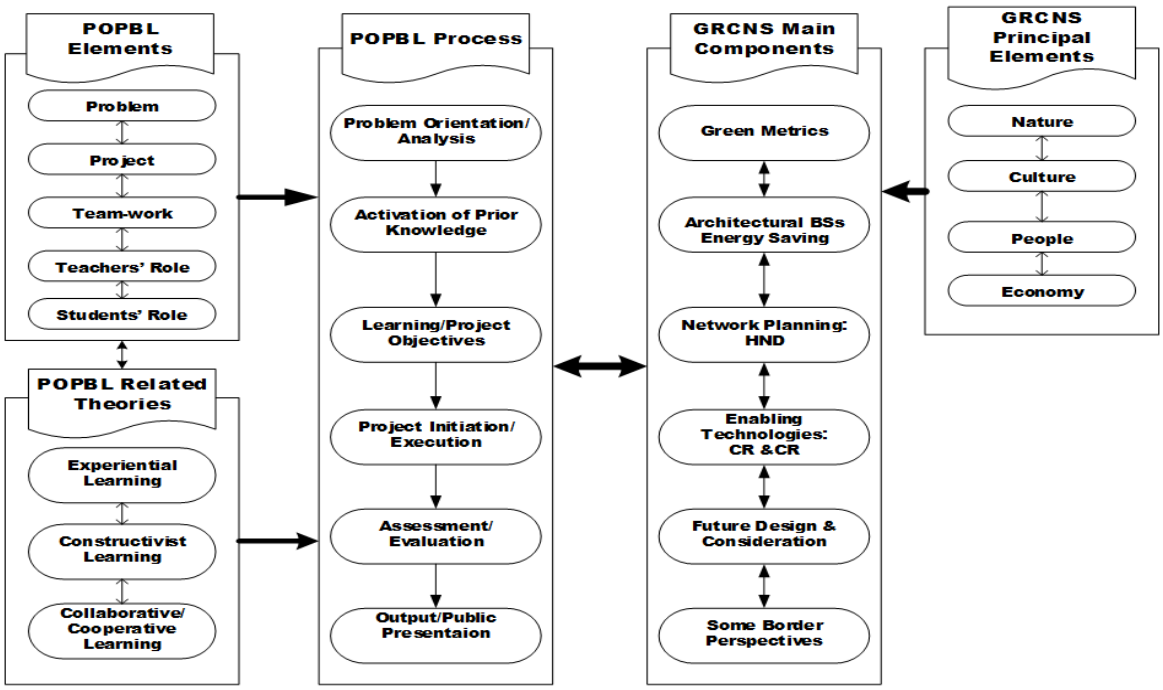

Fig. 1: A POPBL Theoretical Framework

learning experience results in the POBL method. These objectives are not planned to be measurable possibly never to be, but rather serve as a guide for the training plan being focussed. Conversely, the learning goals are not exactly the same as the learning objectives as it designs to evaluate behaviours also the expected learning results with the teaching strategy. Learning objectives are a lot in comprehensive in comparison to the learning goals stating precisely what is expected from the learners at the conclusion of the course or the lesson.

iv. ***Project Initiation and Execution:*** After the problem is analysed and the objectives clearly spelt out, a project is initiated to achieve the set goals and the objectives. POPBL has no definite procedure nor stapes since various projects are stemmed from different problems and have their peculiar objectives which define the steps to be taken. Learning process or even practice procedures in POBL is extremely adaptable and it does not have structured procedures or steps to follow in comparison to the various other learning strategies. Project management skills can be properly utilized at this stage is extremely important in POBL approach since learners will use as well as apply the skills of theirs to plan as well as complete the task. Nevertheless, the learning process could be structured to help the team members to plan their learning process. Learning process of POBL is begun with an end result which the group members wish to develop or even produce. They are going to think and imagine the items within then and share the information within a team. It is the end result which is going to motivate as well as operate the pupils in the entire production, planning and evaluation procedure. Then, they are going to identify who'll be the target customer and who'll make use of the service. This's crucial to be able to specify the scope of the project of theirs so that the work of theirs is going to be more directed and also the project will be finished prior to the dateline. They have to ensure the merchandise they wish to create can give benefit and don't bring some harm by taking into the consideration of theirs what exactly are the implications and negative effects of the item toward the consumer. Right after takes

v. ***Public Presentation:*** The public presentation of the project is a final and important stage of POPBL because the method is aimed at addressing the problems of the society through a project initiation and execution. Presentation skills are very useful both within and outside the classroom [35], [55]. After the completion of a project, a public presentation is a platform for students to share with others what they have learned. It is also an opportunity to challenge and expand on their understanding of the topic by entertaining questions from others [56]. And in the world of work, a confident presenter is able to inform and persuade colleagues effectively. Presentations can also form a natural part of task based learning. By focussing on a particular language point or skill, the presentation is a very practical way to revise and extend book, pair and group work [57]. The audience can also be set a task, for example, a set of questions to answer on the presentation, which is a way of getting students to listen to each other.

A. Theoretical Framework

As shown in Figure I, the resulting POPBL theoretical framework for teaching, learning and research in GRCNS was based on the analysis and synthesis of scientific literature, related modes and frameworks. The POPBL elements were selected based on the demand for problem solving, teamwork and innovation, while the process is based on input, process, and output approach [16]. The POPBL process starts with problem orientation and analysis where an identified problem is broken down into sections or sub-problem with each section given a critical analysis. After the problem analysis, the learners or researchers embark on the activation of prior

knowledge to access their level of readiness in tackling the given problem. Where the existing prior knowledge does not solve the problem, the learners or researcher embark on research to enhance their previous knowledge. Having met the necessary knowledge, the team of learners or researcher set up objectives that serve as guide and benchmark for solving the given problem. The objectives are set based on the analyzed problem as well as best approaches to be utilized in solving the problem which in this case, a project. With the objectives in place, the next stage is project initiation where the project is also divided into sub section based on the analyzed problem and the set of objectives. The project is then designed and logically executed in stages. This could be done through simulation of formative testing and evaluation or re-evaluation till the desired result is attained.

This logical approach can be utilized in the teaching, learning and research in GRCNS with consideration to the principal factors which cover nature, culture, people and economy. The process starts from identifying a problem which could be rooted from any of the four principal factors ranging from environmental damage, health hazard, high running cost, cultural interference and so on. In this case, learners or researchers identify a problem which is caused or could be solved by radio communication systems. The problem is analyzed to identify the fundamental causes of the problem which could result from energy system, transmission system, and receivers and so on. After identifying the fundamental cause of the problem the team consider their already acquired knowledge as well as carry out a research on to mine additional knowledge where necessary. This is followed by material selection, design and execution of the project.

VI. CONCLUSION & RECOMMENDATIONS

This article presents a POPBL theoretical framework for the teaching and learning as well as research in GRCNS. The framework developments is based on input, process and output approach of solving problem through projects. Based on the reviewed scientific literature and related framework, the utilization of this framework in GRCNS help in the development of generic skills like problem solving skills, critical thinking, creativity, teamwork, continues learning and so on. Teams of researchers and engineers can apply this logical approach in solving various problems caused by radio communication technologies.

The development of a POPBL environment for GRCNS was necessitated by the need for energy efficiency, which is a shift from the conventional radio communication systems and its consequent carbon footprint. The choice of a POPBL environment is due to the effectiveness of the method especially in the teaching and learning of engineering and related courses. Various research findings have shown that, the use of POPBL has the potentials of developing sellable and useful skills like problem solving, innovation, creativity, critical thinking, and teamwork and so on. These skills have the potentials of realizing the goals of GRCNS which include: minimizing the carbon footprint of communication networks; Improving operational sustainability in wireless networks; minimizing the monetary price for operators to transmit; Allowing software QoS to be attained within network source constraints; Reducing load on the network and hence per transaction power consumption; Bridging the digital divide between rural and urban areas and; Contributing to manufacturing standards.

The above goals can be attained through the core components of GRNCS like: energy efficiency metrics which deals with energy consumption at the Base Stations (BSs) at the components level; effective minimization of BSs energy consumption in power amplifiers, designing power saving protocols, implementing cooperative BS power management, using renewable energy resources and bringing some simple architectural changes; network planning energy efficiency; system design with emphasis on cognitive radio and cooperative relays; different perspective on future wireless systems [3], [11]–[13].

To realize the goals and beyond, the individual interrelated components must be developed and re-developed by considering the key principles of GRCNS like:

i. Nature, with the aim of making non-exploitative designs that are inspired by nature, system sustaining, linking result with nature and within the limits of nature.
ii. Designs with Cultural values where designers can help change views by proposing human-centered perspective grounded in fundamental values, cultural diversity and deep sense of fulfilment.
iii. Innovations that inspire change and foster sustainable behavior, consideration for human rights and knowledge sharing.
iv. Economic inclined designs aimed at investing in expertise and uncovering new opportunities, resource saving with focus on value instead of profit.

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