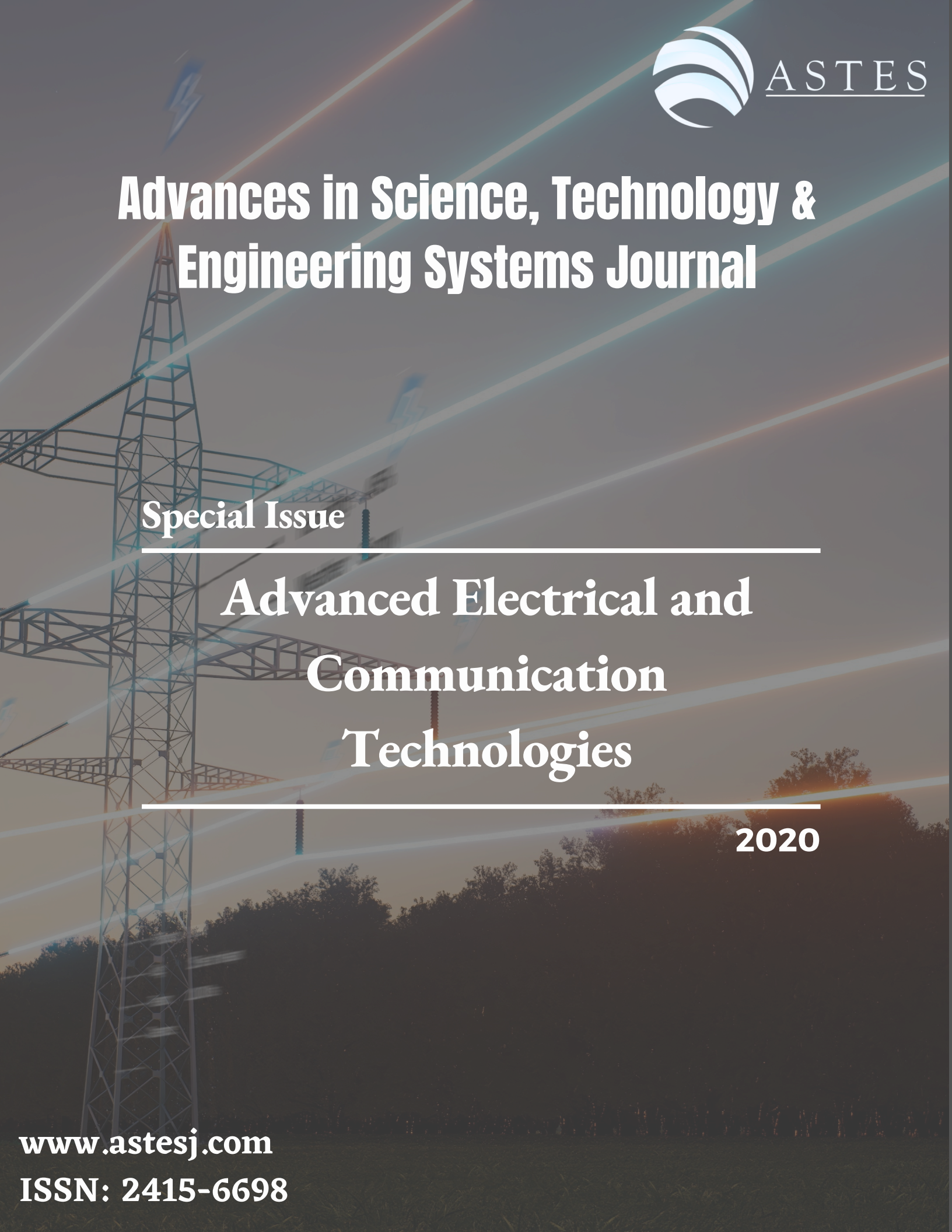

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Special Issue

Advanced Electrical and Communication Technologies

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Editorial

The Special Issue on Advanced Electrical and Communication Technologies (2020) in the *Advances in Science, Technology and Engineering Systems Journal (ASTES Journal)* presents a timely collection of research addressing the rapid evolution of electrical engineering and modern communication systems. As global connectivity and energy demands continue to expand, innovations in these domains play a central role in enabling efficient, reliable, and intelligent infrastructures. This issue brings together contributions that reflect the dynamic interplay between theoretical advancements and practical implementations, highlighting the transformative impact of emerging electrical and communication technologies.

A key focus of this special issue lies in the advancement of next-generation communication systems. Several papers explore developments in wireless communication, including enhancements in signal processing, spectrum utilization, and network optimization. The emergence of high-speed, low-latency communication frameworks is examined alongside enabling technologies such as 5G networks, software-defined networking, and adaptive communication protocols. These contributions underscore the importance of robust and scalable communication architectures in supporting the growing demands of data-intensive applications and interconnected devices.

In parallel, the issue emphasizes progress in electrical engineering systems, particularly in power generation, transmission, and distribution. Research on smart grids, renewable energy integration, and energy-efficient power electronics demonstrates the field's shift toward sustainability and resilience. Authors investigate innovative approaches to grid stability, fault detection, and load management, reflecting the increasing complexity of modern electrical networks. The integration of intelligent monitoring and control mechanisms further highlights the convergence of electrical engineering with digital technologies.

Another notable aspect of this issue is the convergence of electrical and communication technologies within emerging paradigms such as the Internet of Things (IoT), embedded systems, and cyber-physical infrastructures. Contributions in this area illustrate how interconnected sensing, communication, and control systems are enabling smarter environments, from industrial automation to urban development. This multidisciplinary perspective reinforces the role of integrated technologies in addressing contemporary challenges across sectors.

The methodological approaches adopted across the papers are diverse, encompassing analytical modeling, simulation-based studies, experimental validation, and real-world case applications. This breadth ensures both academic rigor and practical relevance, allowing the findings to inform future research, industry practices, and policy development. Many studies emphasize reliability, efficiency, and scalability, offering solutions that can be adapted to evolving technological landscapes.

The year 2020 provides a significant context for this collection, as the increasing reliance on digital communication and stable energy systems became more pronounced under global disruptions. The research presented in this issue reflects a broader shift toward resilient and adaptive infrastructures capable of supporting continuous connectivity and sustainable energy usage.

The editorial team expresses its sincere appreciation to the authors for their valuable contributions and to the reviewers for their meticulous and constructive feedback. Their combined efforts have ensured the high quality and relevance of this special issue.

This special issue offers a comprehensive perspective on the advancements shaping electrical and communication technologies, emphasizing their critical role in modern society. By bridging theoretical innovation with applied research, it provides a foundation for continued progress in developing efficient, intelligent, and interconnected systems that meet the demands of an increasingly complex world.

Guest Editor

Prof. Nabil Srifi

ADVANCES IN SCIENCE, TECHNOLOGY AND ENGINEERING SYSTEMS JOURNAL

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How Ready is Renewable Energy? A Review Paper on Educational Materials and Reports Available for the Teaching of Hydrogen Fuel Cells in Schools

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ABSTRACT

Today, the costs of most Renewable Energy (RE) technologies especially hydrogen energy technologies such as fuel cells, are still beyond the means of poorer economies in developing countries. Hence, there is little public awareness and local expertise in RE in these countries and even lesser in hydrogen energy. To solve this problem, it is important to train local manpower in RE, starting with enabling local schoolchildren to learn about RE, especially hydrogen fuel cells. RE provides an alternative, sustainable and clean energy that improves the environment and human life, expands the choice of available energy sources that improves energy security, and reduces consumption of fossil energy in electricity generation and public transportation. Hence it is critical that teaching modules for exposure, acceptance and uptake of RE technologies are developed to suit local conditions. The purpose of this paper is to review recent progress and advances in RE education especially in hydrogen fuel cell. Important features of the modules, educational materials and reports are discussed critically. This paper assesses the literature on RE teaching in schools, especially in hydrogen fuel cells, and discusses the problems faced and the optimal period for cost-effectiveness. A curriculum that integrates literacy and social concepts with science, technology, engineering and mathematics (STEM) concepts could be developed in the future. The literature shows that teaching and learning of fuel cells could be achieved by using the five "Es"; Engagement, Exploration, Explanation, Elaboration and Evaluation, and also by promoting collaboration, team work, communication and design in project based learning activities. Most teaching materials include a project for students to build their own single-cell Proton Exchange Membrane (PEM) fuel cells and electrolyzers, and to produce hydrogen by using solar energy. Appropriate and economic criteria are developed for the design and development of modules for teaching and learning of hydrogen fuel cells, which could be implemented in physical classrooms or on free blended online learning platforms during the COVID-19 pandemic.

1. Introduction

Since the international oil embargo crisis in the 1970s that had threatened energy security of the world, the idea of developing Renewable Energy (RE) has been widely acknowledged as a measure to stave off a recurrence of the embargo. The increasing acceptance of RE has been primarily attributed to the depletion of fossil fuels especially after the oil embargo crisis. Climate change

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caused by global warming due to carbon emission has been cited as the second most important driver for acceptance of RE. Climate change had manifested itself many times in extreme weather events such as intense heat waves that had hit several European countries such the UK in 2013 [1] and East Asian countries such as South Korea between 2009 and 2012 [2]. Acceptance of RE would reduce the effects of climate change.

Access to energy, energy efficiency and sustainability are the most popular issues in renewable energy (RE) [3]. RE has been found to have a controlling impact on carbon dioxide emissions and therefore climate change [4] and also a positive contribution to a country's economic production [4]-[6]. However, empirical evidence from sub-Saharan African countries have shown that the adoption of RE has not improved their economic power [7]. In addition, RE subsidies in advanced countries have resulted in high RE taxes to finance them that have imposed a heavy burden on consumers [8]. The economic gains and environmental costs of key energy materials such as rare earths are also important issues for and against RE technologies [9]. Furthermore, the high cost of renewable energy needs to be reduced significantly so that RE is no longer beyond the means of poorer economies in developing countries. For example the cost of RE biodiesel could be lowered by using low-cost renewable raw materials such as residual edible oil, inedible oil (*Jatropha curcas* and *Camelina sativa*) and seaweed [10].

The RE economy is a green economy that could provide significant employment in developing and developed countries [11]. In this case, employees and their leaders must be educated in green RE job markets. "Green-collar" workers play a vital role in the development of RE technologies. Students from various level ranging from technical and vocational diplomas in high schools, and science and engineering degree programs in universities could contribute to the sustainable development of the human resources for RE economy [11]. A Chinese study shows that there is a secondary relationship between RE and income [12].

Fuel cells convert chemical energy from molecular bonds in hydrogen and oxygen into electrical energy by an electrochemical reaction. A PEM (Proton Exchange Membrane) fuel cell or PEMFC uses hydrogen gas (H_2) and oxygen gas (O_2) from the air in the reaction and produces electricity, water, and heat. Currently research on PEMFC is focused on developing proton exchange membranes that could operate at high temperature for the High-temperature Proton Exchange Membrane Fuel Cell (HT-PEMFC) [13]. If hydrogen is produced using RE, the green hydrogen so produced could be classified under RE as well.

For Malaysia to stand out in RE technology, there is an urgent need to introduce and integrate RE education into the educational curricula in schools. Although teachers' knowledge content on RE could easily be developed to a satisfactory level, RE education might repeat a major pitfall in science education in Malaysia, which is the inability of science teachers to transfer their knowledge content to the students effectively [14]. Therefore, an essential goal of science or engineering education is to enable these teachers to convey their knowledge to students effectively.

Table 1: Nomenclature Table

No.	Abbreviation	Explanation
1	STEM	Science, Technology, Engineering and Mathematics
2	RE	Renewable Energy
3	PEMFC	Proton Exchange Membrane Fuel Cell
4	HT-PEMFC	High-temperature Proton Exchange Membrane Fuel Cell
5	FC	Fuel Cell
6	HFEP	Hydrogen Fuel Cell Education Program
7	DO	Design Opportunity
8	EiE	Engineering is Elementary
9	STEAM	Science, Technology, Engineering, Arts, and Mathematics
10	FCVs	Fuel Cell Vehicles

This is the first paper in Malaysia to review the readiness of RE education and its educational materials, and available reports on the teaching of hydrogen fuel cell in schools, with the intention of developing teaching modules that could be implemented in the physical classroom. When the COVID-19 pandemic began, there is an urgent need to design and develop modules for teaching and learning hydrogen fuel cells that could be implemented not only in the physical classroom but also conducted online to avoid the pandemic, that is free for all urban and rural children. The authors examine the suitability of these materials to be implemented in the physical classroom and online learning.

The review is intended to provide information, insights and intuitions which would lead the authors and other researchers to develop a cost-effective and economic teaching and learning of hydrogen fuel cells in the country and/or the region. The teaching and learning materials could be transformed into the online learning courses, that is free for everyone. In addition, the blended, interactive online courses with a curriculum created by educators for students and for educators could have the potential of encouraging independent learning, collaboration on projects and hassle-free grading assignments, free for all urban and rural schoolchildren/educators anywhere and at any level, who could learn and stay safe online, avoiding the pandemic.

In this study, we focus upon the recent progress and advances of RE education materials. First, we summarize the objectives of Fuel Cell (FC) education. Then we review the recent features of Hydrogen Fuel Cell Education Program (HFEP) including the teaching method for STEM which includes engineering design, problem solving, collaboration, teamwork, communication and project work. In this part, the science process skills, the design opportunity (DO) element and the design brief which are very important to design and generate solutions to specific problems are

systematically discussed. We also discussed about the recent development in design brief for a project given to the students. Finally, a short conclusion which includes the future perspectives of this RE education materials and challenges in practical application, the cost-effective features and flexibility to be used in blended learning during pandemic crisis are constructively analyzed.

2. Hydrogen Fuel Cell Education Program (HFEP)

2.1. HFEP Objectives

Since the fate of the Earth is in the hands of children, it is crucial and important for them to learn to use RE, and in our case green hydrogen energy and fuel cells at an early age in schools. The main aim of educating schoolchildren on fuel cells and hydrogen energy is to familiarize them with hydrogen energy and fuel cells technology, which would lead to a better, more sustainable, and inhabitable world. The objectives of the HFEP could be summarized as follows

- To accelerate the exposure to fuel cell technology among the schoolchildren
- To encourage the young, who could become future scientists, to perceive fuel cell as an important green energy alternative

2.1.1. Engineering Teaching Method of HFEP

To ensure that the teachers transfer their knowledge content on hydrogen fuel cells effectively to students, a more effective teaching method should be used. One such effective method that we intend to consider is the teaching method for engineering. The teaching method for engineering as suggested by [15], consists of the following fundamental components.

Firstly, the Learning Cycle is summarized as the 5 Es: Engagement, Exploration, Explanation, Elaboration and Evaluation. This is very similar to Bloom's cognitive taxonomy. The first E is Engagement where students are challenged and thought-provoked by reading aloud stories to stimulate imagination and to encourage sharing of ideas. The second E is Exploration where students are encouraged to discover scientific and engineering principle by themselves. This is followed by the third E for Explanation where students explain what happen in different situations and learn from them. The fourth E is Elaborations where students use the knowledge gained to design engineering artefacts. The final E is evaluation where students reflect on their learning curve [15].

Secondly engineering teaching method is contextual learning and problem solving that link their knowledge with the real world by application in problem solving. Thirdly, learning engineering also involves teamwork and collaborative learning in small groups. Fourthly students are also trained in effective communications between team members, clients, and managers. Lastly the engineering teaching method always involve a design project by student that applies all the knowledge that has been learned [15],

The Engineering is Elementary: Engineering and Technology Lessons for Children (EiE) project for American schoolchildren launched in 2003 was a success because it embeds curiosity in the mind of the schoolchildren [16]. EiE not only meet the needs of children, but also expand the ability of primary educators to teach engineering technology. After the EiE project was launched, the number of schools in the United States that embrace engineering in their curricula increased dramatically.

2.1.2. Science process skill

The amount of knowledge that can be obtained from the teaching of comprehensive Science, Technology, Engineering and Mathematics (STEM) is related to how students perceive the effects of STEM teaching [17]. In Thailand, although a high degree of understanding of scientific ideas and concepts and exceptional presentation of scientific process skills are essential for learning science, most Thai teachers have managed to obtain satisfactory performance for these scientific process skills. These include starting the course by sharing the relevant day-to-day situations of the students, grouping the students into groups, making hypotheses, finding information and planning experiments, conducting experiments, collecting data, explaining and summarizing the results. Then share the results with the class, visit the gallery where experimental conclusions are shown, discuss the class summary, and finally determine the possible sources of errors. To succeed, they start with selective science courses, which have less content, so that they could focus more on encouraging skills related to students' abilities and interests[18].

2.1.3. Important features of the engineering design component of a curriculum

The important features engineering design component include encouraging student creativity, following proven design, open ended problems, search for and use contemporary theories, problem statement and specifications, awareness of alternative solutions, and real-world applications [19].

The features of RE education are flexible and amenable to evaluation by both qualitative and quantitative methods. The DO part is more important than a paper and pencil assessment, while collaborative learning and teamwork are prioritized over individual work. Communication skills are essential in engineering education to prepare future engineers. Students must design and find a solution to a problem. After each session, students share their insights on the learning process and make deep reflections.

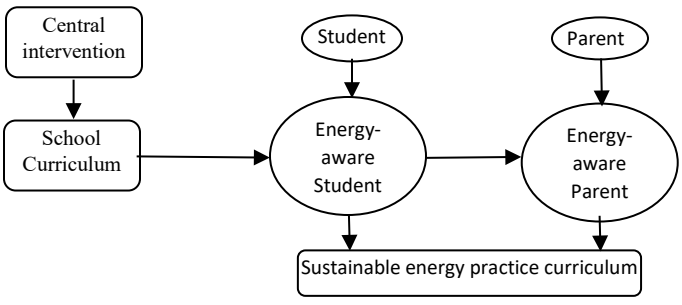

Figure 1: Energy related education channel in society [20]

Experimental work is a large component of learning science and engineering. However, learning how to build a fuel cell does not need to start with complicated experimental works. Hurley (2010) believed that anyone with minimum skills and tools will

be able to build high quality fuel cells from readily available materials. Construction of the cells requires a few hand tools only. Apart from setting up a PV solar panel to generate power for the electrolyzer, he also used the "heart" of the fuel cell, namely, the Membrane Electrode Assemblies (MEAs). In 2013, Hurley published a manual that provides five templates for students to build a solar hydrogen fuel cell system and a fuel cell stack. The components include 40-watt solar panels to run the electrolyzers for generating hydrogen fuel, a simple hydrogen storage, and a 6- to 12-watt planar hydrogen FC stack for generating electricity.

A well designed complete curriculum or enrichment programme is able to educate the students to create a sustainable energy practices lifestyle [20]. Energy-aware students could influence their parents to create energy-aware parents. It is going to be a chain reaction, a domino effect, or a snowball effect in the society.

In one study, parents of 16 years old upper secondary rural children, who had just enrolled to study pure science subjects, were found to have acquired positive values towards science and were willing to support and assist their children to improve their achievements in science. These are crucial factors that can help the educationists to plan RE educational intervention involving parents' support in promoting RE learning and careers [21].

2.2. Design Brief

Practical science activities are insufficient in helping students achieve all their learning objectives. Although design task is given to students in groups of two to four, it is better to wait until everyone has their own design ideas before breaking them into groups. Students must be given freedom to carry out their own investigations or create their own designs to Brown's module. This requires a combination of individual learning opportunities [22], which is could be done in two formats where the students must determine the steps required to achieve their goals, or specific steps were outlined for an experiment. After finalizing team designs, students continue with construction, testing, and presentation preparation and project presentations[22].

Another program that emphasizes the importance of engineering design process as the heart of engineering is EiE. By creating and testing lessons that are closely integrated with elementary science topics, EiE aims to strengthen the science program by integrating it with main engineering concepts, broaden their interests, expand children's images of engineering, fostering positive attitudes towards engineers and expectations for the future. Apart from developing curricular materials and resources, the EiE also conducts workshops for educators in the US. Engineers and teachers are involved in the development of a classroom-tested curriculum. The curriculum also integrates literacy and social concepts with science, mathematics, and engineering concepts [16].

2.3. Integration of Engineering Elements in the Modules

Unlike science, the arts played a large role in the history of engineering. Design, the heart of engineering, is more like arts than science. Modern engineering has also benefited much from science and mathematics. Both fields help the engineer to understand how engineering artefacts behave by simulating mathematically the scientific principles at work in the artefact. Scientific discoveries also provide opportunities for engineers to design novel products that harness the new scientific discoveries to commercialize scientific/engineering products, the arts is used to repackage the product in a much more elegant and attractive manner for the market.

For example, the cell phone is a blend of science, engineering and art. In car industry, science makes the combustion engine work efficiently, while the artistic design of the car complements the masterpiece. In the performing arts, art does not merely refer to acting or singing on the stage but also involves the technology being used at the back-stage.

However, it was only recently that the arts has been integrated into STEM (Science, Technology, Engineering, and Mathematics) to become STEAM (Science, Technology, Engineering, Arts, and Mathematics). An educated person must be able to appreciate art and embrace technology at the same time. The fuel cell is both an engineering and scientific artefact whose invention and design also include the arts.

2.4. Engineering Elements

To integrate engineering elements into the modules, Hershey [23] suggested that students must always be directed by providing them with stimulus after understanding the inventive procedure. The aim of inventing new engineering products should be to improve, enhance, and expand mainstream products to meet social needs. It is important to highlight the importance of merging combinations of elements of many prevailing products to create new products. New opportunities should be recognized by ignoring the rules and using and testing the system. The invention must be "futurized" to ensure the products are up to date. Improve understanding of regulations and use them for innovation. Finally, after completing the invention, you must gather information regarding patent application to protect their rights on the product.

2.5. Economic Features

The experiment or hands-on work need to be simplified by reducing the parts needed so that anyone with minimum skills, tools and materials will be able to produce the product in the teaching manual [24]. A well-designed complete curriculum or programme must be able to educate school children by exposure to RE and FC in an optimal period of time, whose characteristics had been futurized so that it could be updated to suit contemporary circumstances. The teaching module could be implemented in the physical classroom and/or online using blended learning platform that is safe and that eliminates the costs for venue, transportation, etc during pandemic.

3. Hydrogen fuel cells' impacts on securing energy sources and maintaining environmental sustainability

It is important to diversify the types of RE, rather than just relying on specific types. When land and other inputs are transferred from food crops to biodiesel production, the biodiesel industry may lead to competition between fuel and food. [25],

[26]. The biodiesel and oleochemical industries need similar raw materials, which increases their prices. The introduction of biodiesel will directly cause an excessive supply of glycerin, and indirectly lead to a scarcity of oleochemical industry. The glycerin produced must be converted into other useful products. In turn, excessive glycerin will make the price to drop [25].

Malaysia, a major producer of palm oil, produces a lot of wastewater known as the palm oil mill effluent (POME) and empty fruit bunches (EFB) biomass. The adverse impacts of POME towards the environment could be mitigated by reusing the water to overcome water scarcity but reclaiming the water from POME involve cost [27]-[29]. Water treatment by reverse osmosis desalination plants instead of the coventional water treatment plants, incurs higher cost for the integrated/hybrid membrane processes. Usually, a more complicated process is needed for POME treatment such as combinations of membrane filtration unit (microfiltration/ultrafiltration/nanofiltration) with other processes such as adsorption, coagulation, adsorption and ion exchange. [28]. Additionally, natural coagulants could be used with other treatment technologies in integrated/hybrid treatment processes for improved coagulation performance efficiency [29].

Malaysia, a major producer of palm oil, has great potential for H_2 production from POME and EFB biomass by biological treatment but the dark fermentation also produces CO_2 simultaneously. The process is not sustainable until a more reliable and efficient process for separating H_2 from CO_2 is devised and a process to store or reuse the CO_2. The purified H_2 from the gas mixture could be used as a clean source for RE such as in a hydrogen FC [30], [31]. The biogas produced from the further fermentation of POME is already a source of energy around the palm oil mill and could potentially be a major source of RE for Malaysia [31]. Methanol, another fuel for fuel cells, could also be produced from EFB biomass. Methanol FC can be directly applied in mini air vehicles [32].

The success of any bioenergy project is not only determined by technical viability but also by non-technical factors such as authorities, engineers, feedstock producers, and the concerned public [33]. Students have little introduction and experience with hydrogen fuel cells. Hence, students' perception of environmental friendliness of hydrogen fuel cells falls to the eighth, below solar, wind, hydro, wave, natural gas, tidal and geothermal. See Tab. 1 [34].

Table 2: Student perception of environmental friendliness of energy sources (in percent)

Energy Sources	Not Friendly	Little friendly	Less or more friendly	Friendly	Very friendly	Friendliness rank
Natural gas	4.7	10.3	32.5	33.8	18.8	5(52.6)
Solar power	2.6	5.1	8.1	26.9	57.3	1(84.2)
Hydropower	3.8	11.5	24.4	29.9	30.3	3(60.2)
Wind power	4.3	7.3	12.4	21.4	54.7	2 (76.1)
Geothermal power	4.3	16.7	33.3	25.6	20.1	7 (45.7)
Nuclear power	56.8	16.7	16.7	5.1	4.7	14 (9.8)
Coal	47.0	23.1	17.9	5.6	6.4	13 (12.0)
Oil	58.5	18.4	9.0	4.7	9.4	12 (14.1)
Wave power	9.8	15.4	21.4	26.1	27.4	4 (53.5)
Tidal power	5.6	20.1	28.6	24.4	21.4	6 (45.8)
Biofuel	20.1	22.2	24.8	25.2	7.7	9 (32.9)
Waste (burning)	41.9	23.9	16.7	13.2	4.3	11 (17.5)
Biomass	14.5	24.4	28.2	22.2	10.7	9 (32.9)
Biogas	11.5	20.9	37.2	21.4	9.0	10 (30.4)
Hydrogen fuel Cells	16.2	18.8	26.9	20.5	17.5	8 (38)

Sources:[34]

4. Number of textbooks or references available for teaching fuel cell

For design projects, no manuals, textbooks or workbooks have been provided for students [15], [16] Instead, there are five EiE steps of engineering design process that must be followed: ask, imagine, plan, create, and improve solutions to the given engineering challenges. After the project is accomplished, evaluation is carried out by using a combination of qualitative and quantitative measures.

A Textbook on the introduction of RE technologies in the United States have been published [32]. The one-year science and technology course contain 11 modules. The author associated energy science, fossil fuels and climate change, explores the use and preservation of energy in houses, and establishes energy-efficient energy sources such as solar energy, energy wind energy, hydrogen and fuel cells, biomass energy, biofuels, geothermal energy and hydropower.

Hydrogen fuel cells have attracted widespread attention, and its applications in sustainable transportation have been debated. An introduction to hydrogen is provided, followed by a project for students to build their own fuel cells. The fuel cell kit that includes PEMFC and electrolyzers, could be bought from www.fuelcellstore.com. The student would also need a small solar PV panel to provide the energy to produce the hydrogen. Students are given a fuel cell invention design brief. After students complete their team's mission, each team had three to five minutes to introduce their project. The teams then develops special product handbooks for the inventions. After studying all types of RE, the "RE Final Project" is conducted in 10 to 45 minutes of teaching time or five stages of teaching time. Based on the selected RE source, students developed and tested their design brief. Students not only introduced their projects to the class, but also introduced their projects to school members and local public [32].

The number of textbooks on substitute energy and sustainable energy in the region and the rest of the world is very inadequate. More textbooks need to be written according to local conditions to speed up the adoption of RE in the region. The fundamental physical and technical principles of RE to generate energy, and its impact on the socio-economic and environmental.

5. Country Comparison in Terms of Their Readiness to Embrace FC Technology

After the hydrogen fuel cell is identified as one of the most sustainable, clean and efficient energy sources, the next century is predicted to become the hydrogen era [48], [49]. Hydrogen Fuel Cell Vehicles (FCVs) are expected to have a key influence in energy security and preservation of environmental sustainability.

Table 2: FC Education Materials and Reports Available

Name	Link and Contact	Synopsis	Educational Level
"Build Your Own Fuel Cells"	http://physics.csusb.edu/~tusher/share/Fuel_Cell/build_fuel_cells_05.pdf [35]	Hard / soft convection single slice fuel cell construction. Fuel cell design.	Adults and tenants (not appropriate for children without close supervision of adults familiar with fuel cells) Reached more than 9,600 teachers
"Education And Outreach (By Fuel Cell Technologies Office)"	https://www.energy.gov/sites/prod/files/2014/05/f15/fcto_education_and_outreach.pdf [36]	Professional development for teachers Seven video clips • Developed a two-week study plan. High school student module K-12 project goals • Provide tutoring and training. For the hydrogen and fuel cell future generation of labour market • Together with current K-12 school curriculum, test the developed hydrogen and FCtechnology • Introduction to hydrogen science and technology in the highschools and primary schools classroom • Run professionals development plan for high school and primary school teachers who will use the course materials x Determine the superiority and efficiency of the course materials • Expand communication chances with new companion • Distribute the curriculum and workshops apparatus to the whole country via teachers' training and other training programme.	Reached more than 9,600 teachers
"Washington State Fuel Cell Education and Demonstration Program (DOE Hydrogen Program)"	https://www.hydrogen.energy.gov/pdfs/progress04/vii3_vowles.pdf [37]	Develop FCcourses for high schools. Trained 200 junior and senior high school teachers on hydrogen and fuel cells • Provide hydrogen and fuel cell teaching to 18,000 high school students in Washington State. • • Assess the efficiency through an online questionnaire. Proton exchange membrane fuel cell (PEM) demonstration at Central Washington University. • Offer college students with an internship to learn about fuel cells.	Train 200 junior and high school teachers and develop high school curriculum.
"DOE Hydrogen Program. 2004 Annual Program Review Education Overview"	https://www.hydrogen.energy.gov/pdfs/review04/ed_1_cooper_04.pdf [38]	Reach a fourfold increase in the number of students and teachers who understand the concept of hydrogen economics and its impact on hydrogen economics _ Reach a fourfold growth in the number of state and local government councils who know the idea of hydrogen economy and how this economy can influence them _ Double the number of big-scale end users who understand the concept of hydrogen economics and its impact on them _ Introduce a comprehensive and community awareness campaign pertaining Hydrogen economy and fuel cell technology	Teachers and students; public
"Tykey Truett Oak Ridge National Laboratory 2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review Baseline Program Assessment"	https://www.hydrogen.energy.gov/pdfs/review04/ed_2_truett_04.pdf [39]	Measure the existing level of awareness; establish a benchmark for evaluation	General public; State and local government agencies; educators, students and Possible important consumers

"Fuel Cell Demonstration with Onsite Generation of Hydrogen"	https://www.hydrogen.energy.gov/pdfs/review04/ed_p1_turner_04.pdf [40]	Awareness and education Demonstration of hydrogen fuel. Zero emissions from source to sink	Introduce hydrogen in the K-12 education plan; Launch public awareness program; University
"Development And Demonstration of PEM Fuel Cell Educational Program For School and University Communities"	https://www.hydrogen.energy.gov/pdfs/review04/ed_p3_peters_04.pdf [41]	Development and operation task 1 - Development and operation of educational courses.	Middle school, high school, teachers, community and government leaders.
"The 2004 DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Review Lansing Community College Alternative Energy Initiative"	https://www.hydrogen.energy.gov/pdfs/review04/ed_p4_borger_04.pdf [42]	Advocate National Energy Policy to Integrate in energy sources that are dependable, economic and ecologically embrace the future of America. Improve explosure and knowledge of alternatives Including the energy from hydrogen fuel cells. • Create comprehensive training Program for technicians who can support alternatives energy technologies as an effort to increase feasibility and spread RE technology Utilise the new West Campus educational facilities to display other energy applications consist of: i)Wind; ii)Solar energy; iii)Geothermal iv)Biomass and v)Fuel cell	Workforce (including K-12).
"Hydrogen, Fuel Cells & Infrastructure Technologies Program Review Share Technologies Transfer Project (STTP)"	https://www.hydrogen.energy.gov/pdfs/review04/ed_p5_griffin.pdf [42]	Cooperative process with the national industry to share technology developed by the Navy; Raise awareness of private companies to hydrogen and FC including Infrastructure Technology (hydrogen) Program	Manufacturing and university educators.
"Montana Hydrogen Futures Project (New Project)"	https://www.hydrogen.energy.gov/pdfs/review04/ed_p6_bromenshenk_04.pdf [43]	Highlight hydrogen technologies in the development of educational plans and facilities when training energy technicians ; Hydrogen Safety Center; education / interactive website for training or communication	Energy Specialist
"Fuel Cells 2000 --- Fuel Cell for Education"	https://www.utc.edu/college-engineering-computer-science/pdfs/fuel-cells-for-education.pdf [44]	List of existing corporations and educational products.	All school and academia levels.
"leXsolar-H2"	https://lexsolar.com/products.html?isorc=755 [45]	Directory of course packages on RE.	All schools and TVET levels.
"MudWatt NGSS Teacher's Guide"	http://www.fuelcellstore.com/downloads/mfc/mudwatt-main-module.pdf [46]	Microbial Fuel Cell (MFCs) Training Module	Junior high schools
"Implementation of the MudWatt™ Microbial Fuel Cell"	http://www.fuelcellstore.com/downloads/mfc/nsf-mudwatt-module.pdf [47]	Assembly of MudWatt ™ sediment microbial FCby students teach them how to generate energy through electrochemical reactions.	Physical Science class (9th grade)

An effective transition to a sustainable energy system requires public and private sector funding. Many studies have investigated the Purchase Intention (PI) and buying behaviour of hydrogen FCVs and Alternative Fuel Vehicles (AFCs) in Malaysia. Many researchers have started studying hydrogen FC vehicles, while others have conducted rigorous reviews of whether attitudes, subjective norms (SN), and control of perceived behaviour are related to customers' Purchase Intentions (PI) and whether there is a significant association with Purchase behaviour of hydrogen FCVs in Malaysia. These studies are very important for the

decarbonization of the transportation sector in Malaysia and other countries under similar economic conditions[50].

5.1. Malaysia

Of the more than 10,000 schools in Malaysia, about 809 have no power for the whole day, which is particularly common in Sabah and Sarawak. RE sources such as solar panels, wind turbines and micro hydropower plants can meet the electrification needs of rural areas. Take the Penontomon Elementary School (N 4 ° 52.73'E 116 ° 15.9 ') in the Sabah as an example. A solar wind hybrid system was installed to power the guardhouse, tutorial room, computer laboratory and teacher quarters [51]. Before Malaysia can absorb hydrogen fuel cells on a large scale, much work remains to be done.

The biggest benefit of hydrogen is zero emissions, which could help Malaysia achieves the COP15 carbon emission target. Primary energy resources can be used to produce hydrogen in many ways. Hydrogen can be used for transportation, has portable and stationary applications, and could replace fossil fuels [32].

Research and development in hydrogen energy and fuel cells in Malaysia started in Universiti Kebangsaan Malaysia (UKM) in 1995. It was kick-started when a large project of RM 2 million was awarded jointly to UKM and Universiti Teknologi Malaysia (UTM) in 1996 for 5 years from the Intensification of Priority Research (IRPA) fund from Ministry of Science, Technology & Innovation (MOSTI). The same team was granted a much larger project that is 15 fold larger than the first one amounting to RM30 million from the same fund and Ministry in 2002 for 5 years. UKM and UTM team won another large grant of RM7 million from the Ministry of Higher Education (MOHE) in 2013 for 3 years.

It was with this fund that the Fuel Cell Institute (FCI) was established in UKM. The research and development done at FCI are fuel cell system engineering (PEMFC systems), fuel cell electrochemical processes, photoelectrochemical cells, solid oxide fuel cells, direct liquid fuel cells, microbial fuel cells, hydrogen production and solid-state storage and biohydrogen.

Yayasan Sime Darby (Sime Darby Foundation) gave an endowment of RM15 million to establish the UKM-YSD Chair For Sustainable Development: Zero Waste Technology to conduct research and development on hydrogen and biogas production from POME and EFB biomass for power and steam generation, UKM-YSD Chair in collaboration with FCI UKM built a pilot demonstration plant for biohydrogen and biogas production from POME and EFB biomass, CO_2 separation and hydrogen purification and CO_2 storage in algae at a Sime Darby's KKS Tennnamaram, Selangor, Malaysia. A FC buggy is also built to use hydrogen produced by the pilot plant [52].

Recently, Petronas Research Sdn Bhd (PRSB) has granted a large research project of RM 8.25 million to establish the UKM-Petronas Chair of Sustainable Hydrogen Energy in 2019 to conduct research and development on green hydrogen production technology for 5 years. PRSB-UKM is developing new type of electrolyzers at pilot plant scale and plans to built a large FC buggy and start research and development of photoelectrochemical cells.

The extensive R&D of fuel cells and hydrogen energy in Malaysia over 25 years warrants the introduction of fuel cells and hydrogen energy in the school curriculum in Malaysia. Using a battery and FC based system, a project was carried out in a municipal house in Kapit Village, Sarawak [53]. The same configuration can be used for schools in remote areas in other states of Malaysia. Some Malaysian institutions promoting hydrogen FC education mainly focus on PEMFC technology to provide energy for single-seater vehicles [54]. Following the launch of the fuel FC golf buggy of the FCI UKM and the fuel cell/hybrid electric scooter of Taiwan Chengda National University [36], educators can improve the application of fuel cells by introducing FC programs in their schools through an engineering design teaching module[55].

5.2. Japan

Japanese automakers Honda and Toyota have begun to introduce fuel cell vehicles into their products range [56], [57], [58]. The public showed a positive attitude towards hydrogen infrastructure, but expressed concern about the balance between risk of hazards and benefits brought by FC vehicles [59]. An online study conducted to determine the public's attitude towards installing hydrogen refueling stations near residential areas shows that gender gap need to be reduced through education because men accepted more than women. [60].

5.3. Taiwan

In recent decades, the Taiwan government has actively encouraged FC invention through the national invention system. In [49], vocational education and training (VET) is usually a significant subsystem. Many academic and research institutions in Taiwan have also defined policy tools related to VET[49].

5.4. Africa

In the Eastern Cape Province of South Africa, numerous primary and secondary schools have started to apply hydrogen fuel cells to generate energy reserves. This power supply is used to power devices such as computers, fax machines, and tablets [61].

5.5. US

In Woodbridge, Connecticut, Amity Regional High School uses FC energy to generate 2.2 MW of combined heat and power (CHP). There were fuel cells with small 1.4 MW CHP used in Santa Rita Jail in California [62]. FC teaching not only in schools and universities but extended to national level. The California Fuel Cell Partnership and the Pacific Northwest National Laboratory have conducted hydrogen safety first aid training programs for more than 15 years [63]. The resources developed can be used for advanced general lectures or classroom training, depending on the level of understanding of the demographic of the target group [64].

5.6. European Union (EU)

In 2010, school students in Europe did not learn hydrogen and fuel cells in formal education. There are few textbooks about

hydrogen and fuel cells, and plans are made to introduce hydrogen as a suitable future energy source for transportation sector [65]. In Cologne, a German industrial city, the JIVE and MEHRLIN projects conducted tests in five European countries: Denmark, Germany, the United Kingdom, Latvia and Italy. The project spent €125 million (US$133 million) and allocated heavy vehicles including 144 hydrogen FC buses and seven large hydrogen fuel gas stations.

The operation of FCVs is relatively quiet and can reduce noise levels in city areas. In public transportation sector around the world, buses are currently operating, and some success stories have proved their continuous improvement in readiness and consistency. However, due to the lack of FCVs hydrogen refueling stations, the infrastructure is still in its infancy.

Besides modelling of the situation in Normandy, France in 2016, some predictions for 2025 were prepared based on the current assessment of the distribution of hydrogen FCvehicles (FCVs) [66]. Cost-benefit analysis shows that the total cost of ownership of hydrogen kangaroos must be halved. High-power vehicles, such as buses and trucks, have played an important role in increasing hydrogen consumption by further expanding the use of FCVs from Normandy to Europe, as well as using cars, buses, and hydrogen-producing trucks other than kangoos. The two cost components (vehicle cost and fuel cost) involved in deploying an electric FC vehicle (FCEV) can be regarded as a vehicle cost component and a fuel cost component, respectively, and the first component a is more effective than the second component. The cost of introducing hydrogen can be reduced by using a small number of large vehicles to travel on a limited point-to-point route or in a smaller geographic area to promote the widespread use of light hydrogen vehicle [67].

Europeans are aware of the low quality air and noise interference caused by public transportation. Although some cities are starting to use electric vehicles, hydrogen FC buses are still a viable option for most countries that use subsidized diesel buses. Over the past ten years, 84 FC buses operating in 17 cities in 8 European countries have maintained excellent records of flexibility and security. These vehicles can travel up to 300 to 450 kilometers. As a result, there is no need to install infrastructure along the route. If buses and FC cars are mass-produced together, the cost is lower [68].

6. Conclusion and Recommendation

The students must always be guided to provide them with stimulus after exposure to the inventive procedure. In order to invent new engineering products, they should focus on efforts to improve, enhance and expand mainstream products to meet social needs, or to merge useful combinations of prevailing products to create new products and finally to apply for patents. The inventions should also be "futurized" to ensure the products could always be updated.

Soon after the world is tragically affected by the coronavirus COVID-19 pandemic, there is an urgent need to design and develop modules for teaching and learning hydrogen fuel cells that could be implemented not only in the physical classroom but also online learning that is free for all and avoids the pandemic. After examining the suitability of these materials to be implemented in the physical classroom and online learning, it is recommended that a cost-effective and economic teaching and learning of hydrogen fuel cells in the country and/or the region should be developed. The teaching and learning materials could be transformed into the online learning platform that is free for all.

Implementation of the traditional face-to-face teaching is fraught with problems because of the limited period for related programs and difficulty to get a suitable time to do the intervention. This constraint is due to the difficulty of adjusting schoolchildren learning timetables to accommodate the implementation of the new module. Other obstacles to the implementation are the difficulty of getting the support from the school administrators and the availability of the venue.

In the online setting, the introduction part has to be simple, straight to the point, and usually aided with audio-visual media, which are pre-recorded videos from the instructor or merely the shared videos. Tests and game could be done live during the lessons and the students submit their work online. The submission and grading system will be done online. Besides, these blended, interactive online courses with a curriculum created by educators for students, and even educators for educators have the potential to encourage learning, collaboration on projects and hassle-free grading assignments, free for all urban and sub-urban children anywhere and any level, staying safe online and avoiding pandemic crisis.

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Actual Traffic Based Load-Aware Dynamic Point Selection for LTE-Advanced System

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ABSTRACT

Coordinated MultiPoint (CoMP) has been introduced for LTE-Advanced system to overcome the inter-cell interference problems and enhance the signal quality of cell-edge UEs (User Equipments). With such concept, the overall system performance should be improved considerably to support the significantly increasing amount of demand on data transmission via mobile communication that happens nowadays. Dynamic Point Selection (DPS) is one of the major CoMP techniques offering benefit through its practicality and low complexity. This work proposes the actual traffic-based load-aware DPS for LTE-Advanced system. The key important cell selection criterion employed in this work is based on the actual traffic load of the calls along with the UEs received signal indicator. The adapted Vienna downlink system level simulator has been used for the system evaluation. The video streaming traffic model was employed with the data rate of 512 kbps for the realistic use cases and four simulation scenarios including the uniformly distributed UEs case and different patterns of hotspots distribution use cases were deployed. The system performance evaluation includes the system throughput performance, the number of UEs achieving expected data rate, and eNBs' traffic load. The results show that our proposed method offers a substantial improvement over the traditional system as well as the system embedded with the existing DPS mechanisms when the traffic loads are imbalanced such as in certain hotspot cases.

1. Introduction

Mobile communication has entered the fifth generation (5G) with the expectation to support a dynamically increasing number of mobile users as well as the devices supporting IoT services such as e-health, smart metering, and Car2X communication. These mobile services are growing at a compound annual growth rate of 47% as shown in the cisco report [1]. To support such high demand on data transmission with the available radio resource, the Heterogeneous Networks (HetNets) has been deployed. The approach maintains the intended coverage and optimizes the overall system capacity, especially at high traffic demand. In HetNets, the service coverage area is located with cells of different sizes (with different maximum transmit power), referred to as macrocell, microcell, picocell, and possibly femtocells, forming different network tiers. Although, the 5G LTE-Advanced system can gain benefit from an implementation of HetNets, a mixture of cell sizes leads to the complexity in network planning. The Inter-Cell Interference (ICI) caused by the transmission of different base stations in the collocating area will occur especially at the cell edge. Many works have investigated interference management technologies to improve cell-edge throughput. Inter-Cell Interference Coordination (ICIC) has been introduced in LTE Release 8 providing the coordination of neighboring cells in order to mitigate inter-cell interference for UEs at the cell edge. The Enhance ICIC or eICIC was launched in LTE Release 10. The two major techniques under eICIC include the Almost Blank Subframes (ABS) and the Cell Range Expansion (CRE) technique. Using CER, macrocell traffic can be offloaded to the small cells in the same area. The use of Almost Blank Subframes (ABS) results in the key contribution, which is the addition of time domain to ICIC. The signal will be transmitted from the macro-eNB in accordance with a semi-static pattern when eICIC is applied. In these blank subframes, UEs are able to receive the DL information (both for control data and user data) since they are at the cell edge that is normally in the CRE region of the small cells. The performance evaluation of the system embedded with CRE and ABS mechanism with diverse CRE and ABS configurations are investigated in [2].

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The transmission of Coordinated MultiPoint (CoMP) was first mentioned in 3GPP Release 11 [3]. Its main concept is to reduce the inter-cell interference and improve the quality of signal of cell-edge UEs by implementing multi-cell cooperation. The new framework based on the multi-cell Channel State Information (CSI) feedback from the set of cells in a CoMP cluster was introduced. Many mechanisms have been proposed under the umbrella of CoMP. In [4], the integration between Joint Transmission (JT) CoMP and the Non-Orthogonal Multiple Access (NOMA) in the downlink HetNet was investigated. The JT CoMP scheme with the anisotropic path loss model was satisfied for the requirement of the fifth generation (5G) of mobile communication by the author of [5]. In [6], coordinated scheduling CoMP was analyzed in terms of the throughput with different cells. However, the Dynamic Point Selection (DPS) CoMP is the research gap of such work

In this work, the actual traffic load-aware Dynamic Point Selection (DPS) is proposed. The major benefit of the DPS mechanism in general is that it is a simpler approach in terms of practicality since UEs are being served by only one serving cell at a time. Several DPS mechanisms have been proposed previously in [7] and [8] without considering the traffic load condition of the cells. In [9]-[11], DPS mechanisms with cell load consideration were presented. However, the call load was estimated by the average value of the PF (Proportional Fairness) metrics and the current number of active UEs. Unlike the previous papers, this work proposes the actual traffic based load-aware DPS, in which the current traffic load of the cells is considered. The obtained results ascertain that overall system performance can be enhanced as well as the service quality especially in the cases of load imbalanced in the CoMP clusters.

This paper is organized as follows. Section 2 gives a review on CoMP techniques in LTE-Advanced system. This section presents previously proposed DPS approaches along with the traffic model used in the studies. In section 3, the algorithm design of our proposed actual traffic load-aware DPS is described. The simulation model and simulation scenario are defined in section 4. The simulation results are given along with the discussion in section 5. Finally, conclusions are given in section 6.

2. Coordinated MultiPoint in LTE-Advanced System

2.1. The Coordinated MultiPoint (CoMP)

According to [12][13][14], the basic principle of CoMP is to improve the spectrum efficiency by making use of the multiple transmitting and receiving antennas from multiple site locations though they may or may not belong to the same physical cell. Also, by taking the advantage of the co-channel interferences, the enhancement of effective coverage area can be achieved. Although CoMP is mainly used to enhance the cell-edge UE experience, it can be applied to improve the service quality of UEs experiencing intense signal from different eBSs/cells. CoMP can be divided into two terms which are inter-site CoMP and intra-site CoMP depending on the coordinating Transmission Point (TPs). If the coordination is executed between eNBs located at the separate geographical areas, it is the inter-site CoMP. If the coordination is executed among multiple antenna units between sectors of the same BS, it is the intra-site CoMP. Refer to the previously proposed mechanisms, CoMP can be categorized into two types which are; a) Coordinated Scheduling/Beamforming (CoMP-CS/CB) and b) Joint Processing (CoMP-JP).

- **Coordinated Scheduling/Beamforming (CS/CB)**

In CS/CB CoMP, the data packet requiring to be sent to a UE terminal are ready for transmitting from only one BS in the CoMP cooperating set [15], whereas the user scheduling and beamforming decision are dynamically obtained after the coordination among all TPs in the cooperating set is completed. By applying the semi-static point selection, the transmission decision is made. Although fast and strict coordination can be obtained from CS/CB, the selection of the users' best serving set for transmitter's beams construction is still based upon their geographical position. This is because the beamforming in a coordinated manner of CS/CB relies on the capabilities of the MIMO antenna. Focusing on the behavior of the beam to resources selection, as shown in Figure 1(a), the coordinated generation of beams manages not only to obtain the interference reduction among other neighboring users, but also the enhancement of signal strength of the targeted users.

- **Joint Processing (JP)**

The most advanced CoMP scheme that has been commonly applied to achieve spectral efficiency improvement, especially for the cell-edge user, is the JP scheme. In this case, considering the same time-frequency resource, the UE's data is available at more than one TP in the CoMP set. In terms of cooperation mechanisms, there are two main categories of CoMP-JP including Joint Transmission CoMP (JT-CoMP) and Dynamic Point Selection CoMP (DPS-CoMP).

Joint Transmission CoMP (JT): In the JT-CoMP scheme, UE data is processed and transmitted from the multiple cooperating BSs at the same time. Even in the heterogeneous scenario and dense small cell network with low power nodes, the essential signal strength delivered from the multiple BSs can be simultaneously sensed by the UEs. Although the JT-CoMP is the most powerful and attractive approach applied to enhance the efficiency of the spectrum and the average throughput, it requires high system demand in terms of computational power and signaling overhead as presented in Figure 1(b).

Dynamic Point Selection CoMP (DPS): In the traditional DPS-CoMP scheme, UEs can reselect the serving BS by considering the highest received SINR and the minimum path loss. However, the DPS-CoMP is different from the CS CoMP in that all cooperating BSs contain the UE's data in DPS. The UE performs the selection of the best serving BS for its next frame dynamically and then notifies all cooperating BSs of the CoMP set. As shown in Figure 1(c), after the newly serving BS is chosen, it informs the others to refrain from transmission via the X2 interface. This action is done to support the resources that this UE is about to employ. Therefore, the transmission of data is taken place only by one BS at a time.

In the baseline scheme of the DPS, the transmission switching metric can be defined as.

$$S_k^{s,t} = \frac{r_k^t}{r_k^s} \quad (1)$$

where the term r_k^t is the instantaneous throughputs of user k when being served by the TP t and r_k^t is the instantaneous throughput of user k when being served by TP s. In this basic DPS mechanism, the cell load of the eNB is not taken into account for DPS switching metric.

In [10], an instantaneous load-base DPS scheme was proposed. UE's channel and cell load of the serving cell are used to achieve the transmission switching metric. In this case, the transmission switching metric can be derived from eq. (1) by including the cell load representing the eNB load state. As a result, the transmission switching metric of the load-base DPS scheme can be defined as:

$$S_k^{s,t} = \frac{\left(\frac{r_k^t}{\rho_t}\right)}{\left(\frac{r_k^s}{\rho_s}\right)} \quad (2)$$

where the terms ρ_t and ρ_c are the cell load of the transmission point t and s, respectively.

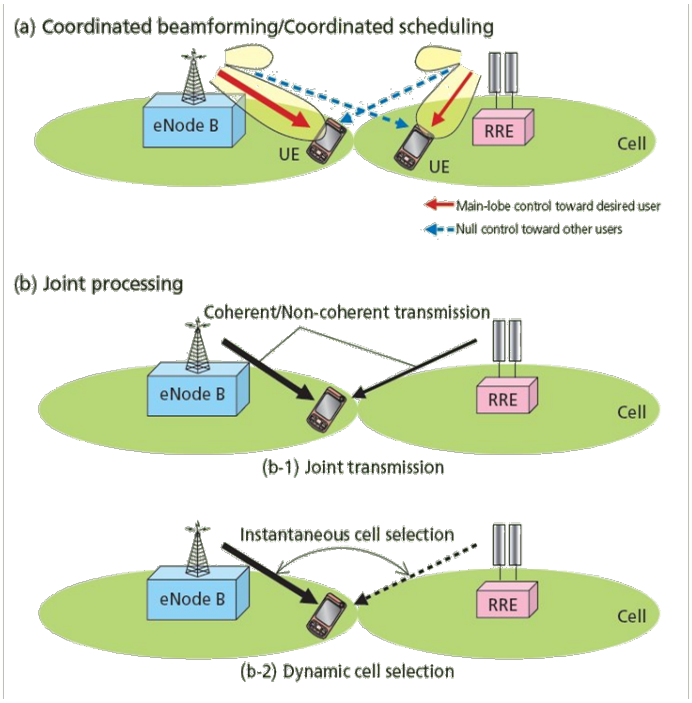


Figure 1: Downlink CoMP transmission [16]

2.2. Traffic Model Studied in DPS

The performance of DPS for LTE-Advanced system has been investigated in several works. The authors of [7] and [9] have analyzed the DPS mechanism in the homogenous networks with the full buffer traffic model. The HetNet case has been implemented in [8]. The authors of [10] and [11] have compared the performance of DPS under bursty traffic model in comparison with the full buffer traffic model. In [17], the DPS mechanism in the HetNet scenario with the FTP traffic model was implemented. Nonetheless, in such a proposed algorithm design, the bursty traffic model and the full buffer traffic modal may not be the best type of traffic to be used. This is because when all UEs use a bursty traffic model or a full buffer traffic model, the cell is more or less need to offer full capacity, which leads to the cell load of around 100% most of the time. With that, the traffic offloading effect is hard to be monitored.

In this work, the video streaming traffic model is therefore focused, which is more or less the most used kind of services in the real world these days. The configurable video traffic model has been developed here and used to analyze the system performance embedded with our DPS with the load-aware mechanism. Table 1 presents the configurable parameters of the video streaming traffic model used in this work.

Table 1: Parameter of the video streaming traffic model

Parameters	Value
Slice size	400 bytes
Slice interarrival time (encoder delay)	6 ms
Number of slice per frame	16 slice
Data rate constraint	512 kbps
Arrival time for all slices	100 ms

3. Algorithm Design of the Proposed Actual Traffic based Load-aware DPS

3.1. Cell Load Estimation

In [7] and [8], the performance of DPS in both homogenous networks and HetNet has been analyzed. Load-aware with DPS was implemented with different mechanisms from our proposed method here. As for the cell load estimation, the authors of [9] define traffic load as the summation of the data traffic from all UEs attached with the cell. There are two approaches for cell load estimated by the author of [10]and [11]. In [10], the cell load is estimated by the average of the Proportional Fairness (PF) metrics of the UEs currently served by that cell.

$$\rho_c = \frac{\sum_{i \in \mathcal{A}_c} \frac{r_i}{x_i}}{N_c} \quad (3)$$

where ρ_c is the traffic cell load of the TP_c, $\mathcal{A}_c$is the set of active UEs currently served by TP_c, and $\frac{r_i}{x_i}$ is the ratio of the PF metric of UE_i. In [11], the cell load is estimated by using the current number of active UEs served by that current cell. However, in reality, traffic load of a cell cannot be estimated by the number of UEs. This is because the traffic demand of each UE is not always the same.

In this work, the actual traffic load of a cell is used for analysis in our proposed system. The actual traffic load estimation used in this work can be defined as:

$$\rho_c = \frac{\sum_{u|X(u)=c} \frac{D_u}{R(SINR_u)}}{N_{tot}} \quad (4)$$

where D_u is the constant data rate requirement of each UEs, $R(SINR_u)$ is the data rate per PRB by user u, and N_{tot} is the total number of resources [18]-[20].

3.2. Algorithm Design

The actual traffic-based load-aware DPS is proposed in this work. The algorithm to reselect the serving cell proposed here is based on the criteria including CQI as well as the cell load condition of the potential TP(s). In the first step, each cell in the simulation scenario is calculated for the actual traffic load by using the equation (4). If the actual traffic load of each cell in eNBs is more than 80%, the targeted number of offloading UEs will be increased, otherwise decreasing the targeted number of offloading UEs. For those congested cells (set here with >80% cell load), UEs with low link quality are considered for changing of a serving cell. The new serving cell that provides the best connection can be chosen from the selection of cells within the CoMP cluster. The offloaded UEs' serving cells will be reselected in case of the offloaded cell has turned congested and the UE receives low link quality. The threshold for maximum cell load has also been set to make sure that offloaded cells have enough capacity to admit additional connections without affecting the currently attached UEs. The algorithm design of the proposed actual traffic base load-aware DPS is shown below.

Algorithm: Actual Traffic base Load-aware Dynamic Point Selection

```
//Initialization
j: Cell
J: Number of Cell
N: Number of offload UEs
M: Number of offloaded UEs

//Calculate actual traffic cell load
for j = 1 to J
    Cellulate actual traffic cell load(j) by eq. (4)
end

//Calculate the number of offload UEs in each cell
Set N to zero
for j = 1 to J
    if actual traffic cell load(j) > 80%
        Increase N(j)
    else
        Decrease N(j)
    end
end

//offload UEs
for j = 1 to J
    if N(j) > 0
        Sorting cell-edge UEs
        Set M to zero
        while N < M
            //offload cell edge UEs
            Offload cell-edge UE (reselect cell eq. (2))
            Increase M
        end
    else
        continue
    end
end
```

4. Simulation Model and Simulation Scenarios

4.1. Simulation Model

The downlink system level simulation has been used in this work to observe the system performance of the LTE-Advanced system embedded with our proposed DPS mechanism, the actual traffic-based load-aware dynamic point selection. The simulator used here was adapted based on the Vienna LTE system level simulator [21]. The adapted model is used to evaluate the system performance under four different test scenarios. Table 2 presents the simulation parameters used in this work.

Table 2: Simulation parameters

Parameters	Value
Bandwidth	15 MHz
Carrie frequency	2.1 GHz
CoMP cluster	3-cell intra-site CoMP
UE speed	3.6 km/h
Antenna configuration	2x2, single pair of cross-pole antennas both at Tx and Rx
Propagation scenario	3GPP Macro Case1, 500 m inter-site distance
Traffic	Video streaming, Data rate 512 kbps
Scheduler	Proportional Fair (PF)
Handover interval	50 ms
Simulation Time	3,000 ms
Number of UEs	Normal load - uniformly distributed with 10 UEs/cell, Hotspot load - 50 UEs/cell

4.2. Simulation Scenarios

The 3-cell intra-site CoMP cluster as defined by 3GPP [3] has been used to define the coordinating area as a UE CoMP set, also known as the co-operating cluster. Figure 2 depicts the 3-cell intra-site CoMP cluster. In this work, this CoMP cluster is used as the COMP clustering pattern in the LTE-Advanced system studied here.

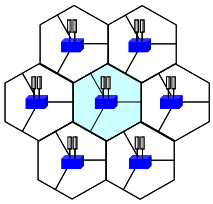
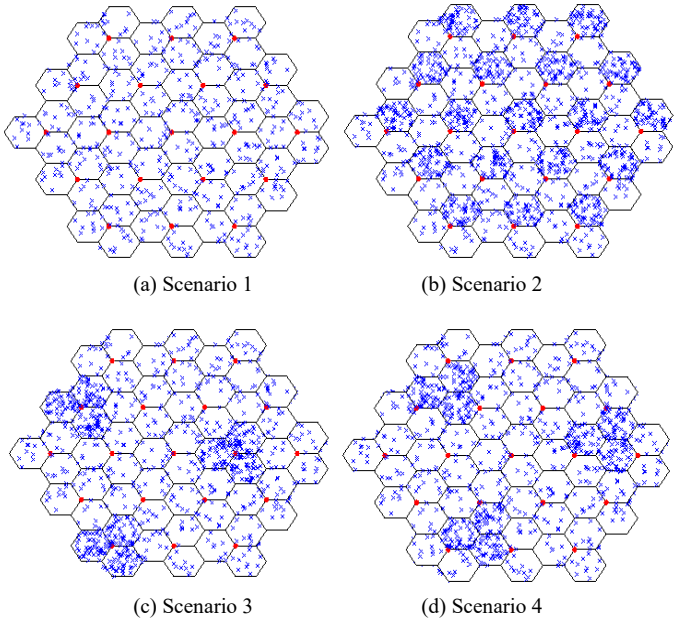


Figure 2: The 3-cell intra-site cluster

Four simulation scenarios have been implemented. Figure 3 shows the plot of UEs distribution within the Region of Interest (RoI) with regards to each simulation scenario. Base on the 3-cell intrasite CoMP cluster, as shown in Figure 2, the test scenarios

were designed in such a way that the system performance under heavy traffic as well as the hotspot type of traffic distribution can be observed. The four simulation scenarios implemented here consists of the randomly and uniformly distributed UEs (with normal traffic load) in scenario 1 and the hotspot scenarios with different hotspots' locations (high load in certain areas) in scenario 2 - 4. There are 19 eNBs or 57 cell sites in the simulation scenario. The red dots in Figure 6 represent the eNB and the blue crosses represent the position of the UEs.

In the first simulation scenario, 10 UEs are uniformly distributed within each cell to mimic the system under normal traffic load as illustrates in Figure 3(a). In the second scenario, one cell in each CoMP cluster (under the coverage of each eNBs) has 50 UEs located in to form a hotspot and 10 UEs on the other cells in the same cluster, as shown in Figure 3(b). There are three scattered hotspots implemented in simulation scenario 3 and 4. In scenario 3, the hotspot cells generated with 50 UEs are in the exact location of the three cells of one eNB. In other words, 150 UEs were located in those eNBs for high traffic demand areas, as illustrated in Figure 3(c). The last simulation scenario is similar to that presented in scenario 3. However, each three 3-cell coverage hotspot was located across three different clusters as can be seen in the Figure 3(d).



(a) Scenario 1 (b) Scenario 2

(c) Scenario 3 (d) Scenario 4

Figure 3: The plot of UEs distribution in the different scenario

5. Simulation Results

In this section, the simulation results obtained from the adapted system level simulator discussed in section 4 are presented. For the comparative studies, different mechanisms have been configured to observe the system performance including the non-DPS system (traditional LTE Advanced system), DPS (with received signal strength-based), and our proposed DPS with load-aware using actual eNBs' real-time traffic situation. The observed results for system performance evaluation include 1) the throughput performance i.e. the peak throughput, the average throughput, and the cell-edge throughput 2) The number of UEs achieving the expected data rate and 3) eNBs' traffic load.

5.1. Peak, Mean, Edge Throughput Performance

Figure 4 – 7 illustrate the simulation results of the test scenario 1 – 4, respectively. The x-axis identifies different types of throughput observed from the simulation including the peak throughput, the mean throughput, and the cell-edge throughput. The y-axis represents the throughput level in Mbps. Different colored bars represent the throughput performance obtained from a non-DPS system (in blue), a system embedded with a traditional DPS mechanism (in orange), and a system embedded with our proposed DPS mechanism (in gray).

The simulation results for test scenario 1 are given in Figure 4. It can be seen that when the system operated under normal traffic load, the system performance in terms of peak throughput, average throughput, and cell-edge throughput provided by implementing the three mechanisms i.e. non-DPS, DPS, and DPS with actual traffic load-aware are the same. This is because with a low number of UEs, traffic demand from the generated UEs is low. Hence, the system is not saturated and has no problem providing good Quality of Service (QoS). As a result, the system embedded with three different mechanisms offer similar performance.

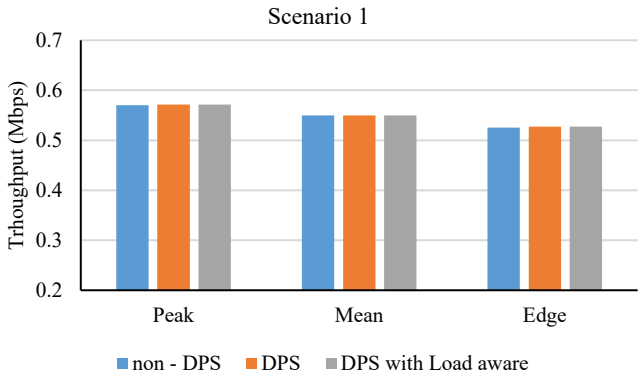


Figure 4: Simulation results from scenario 1

Figure 5 shows the simulation results obtained via test scenario 2. It can be seen that in the case of non-DPS and typical DPS mechanisms, the system performance is similar though slightly higher peak, mean and edge through are offered by the DPS mechanisms. When comparing DPS with load-aware DPS, it is obvious that the throughput performance offered by our load-aware DPS is the highest for peak, mean, and edge. Since in scenario 2, the hotspot is located in one of the three cells in each cluster. In other words, there is a load imbalance among the cells in the same cluster. As a result, traffic can be offloaded from the congested cell to the neighbor(s) (within the same cluster) who handle a small number of UEs. With the load-aware mechanism, the overall system can then be highly improved.

Figure 6 and Figure 7 present the simulated results of the test scenario 3 and 4, respectively. The hotspot cells were allocated with the same number of UEs. However, the positions of hotspot cells are at different locations. In test scenario 3, it can be seen

from the simulation results that system performance obtained using the three mechanisms provides similar results. As in this scenario, although there are hotspot areas with highly generated traffic demand, the high traffic load covers the entire CoMP clusters, which makes it rather impossible to transfer the heavy load to the cell(s) with lower traffic. This is due to the property of the fixed clustering mechanism.

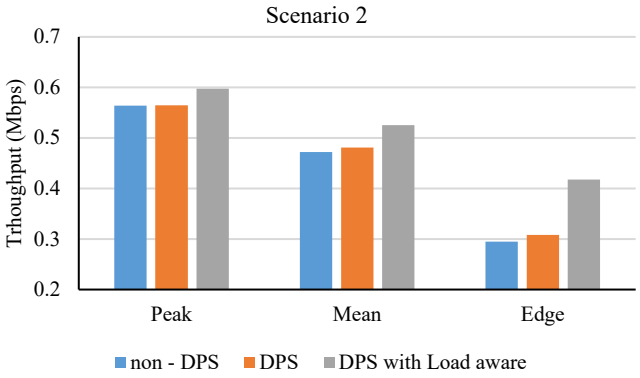


Figure 5: Simulation results from scenario 2

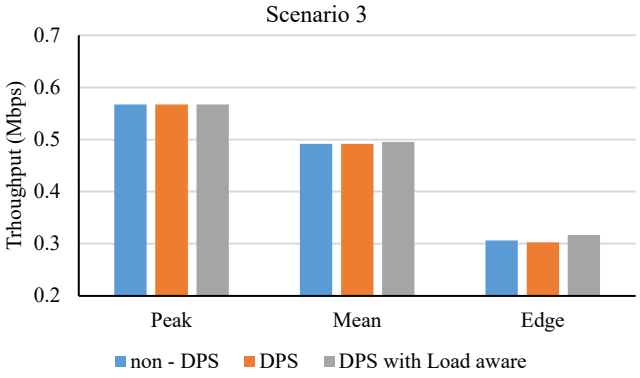


Figure 6: Simulation results from scenario 3

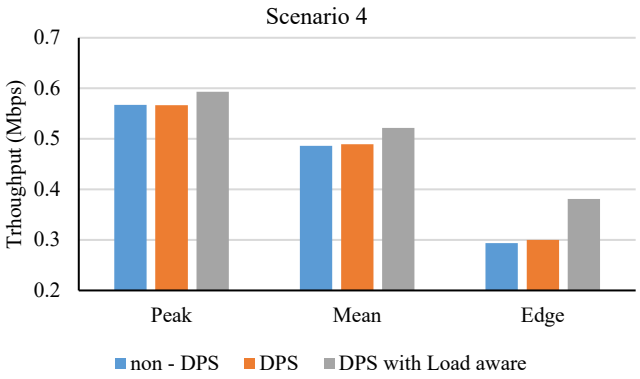


Figure 7: Simulation results from scenario 4

Simulation scenario 4 observes the case when the hotspots' coverages are across the fixed CoMP clusters. From the simulation results, shown in Figure 7, it can be seen that although it has the same number of UEs as in scenario 3, the DPS mechanism offers slightly better throughput performance in general. But When the actual traffic load of eNBs is considered as the main part of the offloading condition, our DPS with a load-aware mechanism provides much better results, especially for the cell edge throughput. It can also be seen that the results from scenario 2 and 4 are very similar, which is due to the ability of the proposed load-aware DPS mechanism in such a way that higher loaded cell can offload some UEs to those with available resources, thereby allowing better overall system performance and capacity.

5.2. The Number of UEs Achieving Expected Data Rate

In this section, the results are presented in the view of users' experience. Note that the video streaming traffic model has been implemented here to mimic the realistic use cases. Figure 8 shows the results for the number of UEs (as in percentage) that achieve the expected data rate (512 kbps) for all test scenarios. The results provide a comparison for the system embedded with non-DPS, DPS, and our DPS with actual traffic load-aware, represented by the blue bars, the orange bars, and the gray bars, consequently.

In simulation scenario 1, all UEs achieve the expected data rate (100%) for all three mechanisms. With low traffic demand, all three systems can maintain system performance. In scenario 2, it can be seen that in the case of the non-DPS mechanism, only 50.3% of UEs can achieve the expected data rate, while the DPS mechanism offers 3.4% higher. Using DPS with load-aware mechanism, the number of UEs achieving expected data rate increases by 16.3% to 66.9% satisfying users. Note that, in this scenario, one-third of the entire simulation plane has high traffic demand. In scenario 3, the number of UEs that can gain the expected data rate is approximately 63% for all DPS mechanisms. It can be concluded that in the event of a hotspot occurring in all cells of the CoMP cluster, no matter what DPS mechanism is used, the system performance cannot be further enhanced as the hotspot cells have entered the saturated stage.

The different situation can be seen from the results of simulation scenario 4. DPS mechanism provides the number of UEs achieving expected data rate at approximately 61%, which is rather close to that of the non-DPS mechanism. On the other hand, when the proposed DPS with actual traffic load-aware is used, the number of UEs achieving the expected data rate increases by approximately 9% to the 70.4% of all users. This is due to the real-time awareness of actual traffic, which each cell is handling, by using our proposed mechanism. As a result, unsatisfying UEs, who are most likely located at the cell edge of the hotspot cells (saturated cell) can be offloaded to the cell in the same CoMP cluster with more available resources (lower traffic).

Coined from the comparison, in the event that the number of UEs in each cell is small, the system is not saturated, thus all UEs can achieve expected data rate. In the case that the number of UEs in some cells of the CoMP cluster is high (saturated traffic), when using the proposed DPS mechanism with load-aware, traffic load can be transferred to other cells in the same CoMP cluster with more availability to handle the new connections, thus increasing the number of UEs achieving the expected data rate. On the other

hand, in case of all cells in a CoMP cluster becoming hotspot or has a high number of UEs, the use of DPS and DPS with load-aware mechanisms only cannot increase the number of users achieving the expected data rate. This leads to the plan for our future work to consider also the clustering mechanism in combination with our proposed DPS mechanism to further enhance the system performance through best resource utilization.

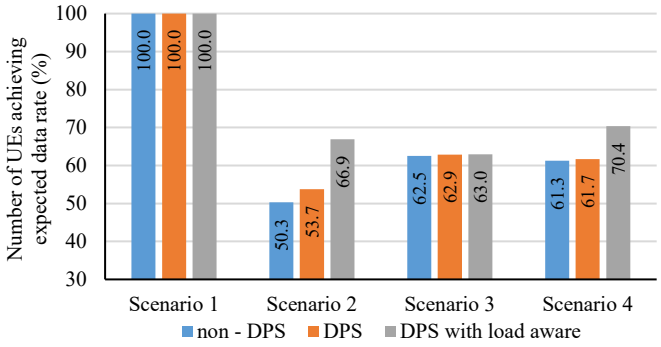


Figure 8: Number of UEs achieving expected data rate

5.3. Offered Traffic Load

Figure. 9 - 11 illustrate the traffic load of each cell (sector) in a CoMP cluster obtained from the scenario 2. Refer to Figure 3(b), each CoMP cluster is generated with one hotspot cell and the other two normal-traffic cells, known as intra-site CoMP cluster. It can be seen that cells with a large number of UEs or hotspot cells are handling a lot of traffic, no matter what mechanism is being used, since the system has been saturated, as shown in the plot of offered traffic in Figure 9.

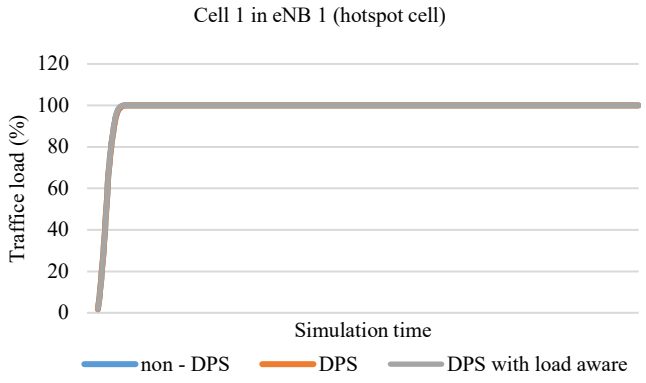


Figure 9: Traffic load of cell 1 in eNB 1 (hotspot cell), scenario 2

Figure 10 and 11 show the traffic loads of cell 2 and 3 in the same CoMP cluster as cell 1. In the case of the non-DPS mechanism, these cells with a low number of generated UEs has offered traffic at approximately 20%, but when using the DPS mechanism, traffic load are slightly higher. In the case of the DPS with a load-aware mechanism, traffic load increases to around 35% and 50% in cell 2 and cell 3, respectively. This set of results confirm that our DPS with load-aware mechanism checks the actual traffic load of every cell in the CoMP cluster and uses that as one major criterion for dynamically selecting the transmission point at each decision-making interval. Hence, when one cell is saturated, the load will be transferred to the other cell(s) in the same CoMP cluster. As seen in the results, the traffic load of cell 1 is offloaded to cell 2 and cell 3. The amount of offloading traffic is not necessarily the same for each cell. It depends on how close the UEs to the cell-edge and the level of traffic loads of the offloading and offloaded cells. Hence, the traffic load results of DPS with the load-aware mechanism shown in Figure 10 and 11 are not the same.

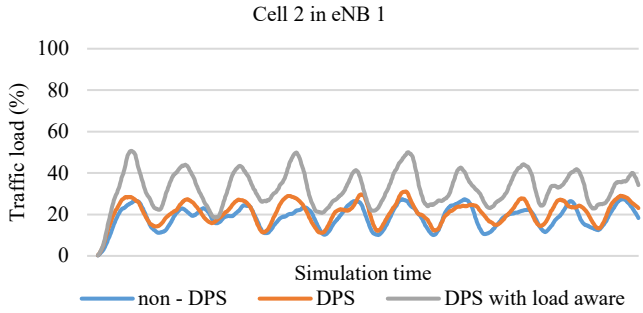


Figure 10: Traffic load of cell 2 in eNB 1, scenario 2

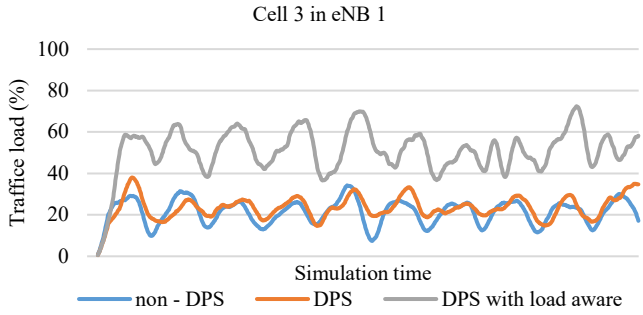


Figure 11: Traffic load of cell 3 in eNB 1, scenario 2

6. Conclusion

In this paper, the actual traffic load-aware DPS has been proposed. The system performance of the traditional LTE-Advanced system, the system embedded with baseline DPS mechanism, and the system embedded with our proposed DPS with actual traffic based load-aware mechanism are investigated. The adapted Vienna downlink system level simulator has been used for the system evaluation. The video streaming traffic model adapted here has been deployed with a data rate of 512 kbps for realistic use cases. The system performance is observed in different dimensions including the throughput performance (peak throughput, mean throughput, and cell-edge throughput), the number of UEs achieving expected data rate, and the traffic load illustrated for each cell in the imbalanced offered traffic scenarios, i.e. simulation scenario 2 implemented here. The four different scenarios have been investigated covering uniformly distributed traffic over the simulation terrain as well as different patterns of hotspot cases. While in the non-saturated traffic case and congestion covering the entire cluster case, all mechanisms perform similarly, our proposed mechanism offers a significant system performance improvement over the other DPS mechanism and traditional system for cases with irregular or imbalanced traffic within a CoMP cluster. As for our future work, a more

flexible clustering mechanism will be studied to further enhance our mechanism.

Conflict of Interest

The authors declare no conflict of interest.

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Customer Behavior of Green Advertising: Confirmatory Factor Analysis

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ABSTRACT

The implementation of green advertising is relatively low for credibility but has an impact on green customer behavior. Based on the phenomenon, the purpose of this study is to examine factors affecting green advertising development, which is based on experienced customers towards products and advertisements and environmental issues. This research focuses on customers to create an implementation model for green advertising among companies. The study was conducted through a survey of 215 customers in West Java (Indonesia) who experienced green advertising and bought environmental-friendly products. Data were collected through a quantitative questionnaire and processed with SmartPLS to test and evaluate Confirmatory Factor Analysis (CFA). In emphasizing the study results, a fit test of the research model and research hypotheses were also being carried out by valuing the KMO. Research findings show several dimensions involved in developing green advertising, such as experience, theme, message, claim, emotion, interaction, and impact. The dimensions of green advertising were plotted in the CFA model so that the priority scale from the implementation of green advertising measurement can be detected. Customers assume green advertising as advertising that takes environmental issues of "global warming," and this issue can adopt by companies in implementing the green marketing strategy.

1. Introduction

Customer behavior has led to environmental sustainability; it is assessed from the increasing level of customer awareness of companies' environmental-friendly products [1]. This phenomenon provides opportunities for companies to adopt environmental-based advertising [2]. Advertisement can influence a customer to choose environmental-friendly products. Environmental-based advertising activities which also known as green advertising, is a marketing strategy that tackle the issue of environmental sustainability and health impacts among users [3]. The implementations of green advertising become important because customers have started to care about the environment with various movements, such as "green consumerism" [4], whereby the activities put forward to customer behavior in consuming and recommending environmental-friendly products [5]. Green customer behavior becomes an essential part of the company's attention in implementing marketing strategy today [6]. The issue of "green product" has become a world issue; people's behavior is changing in every country to be more concerned about the environment as an effort to face the issue of "global warming" [5]. The efforts made by creating environmental-friendly products and decreased the production of goods and services that use chemical materials [7]. The development of environmental issues occurs in several sustainability concepts, including the concept of green living, which is an effort to live a healthier life with the attention and the use of environmental-friendly products [8]–[10].

Green advertising is part of the green marketing strategy that companies used to create awareness of green products [11]. However, the credibility of green advertising is considered low by customer. This is because customer behavior towards advertising is influence by extensive propaganda of mass media [12]. Therefore, the study of customer behavior in assessing advertising is necessary because previous research has demonstrated that the attitudes towards advertising has provided opportunities for brand attitudes changes [7]. In Indonesia, the green advertising concept was started in 2004 and has been implemented by the government to educate the environmental issue, while companies used it for corporate image [13]. The consumer's perceived value of green

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advertising focuses on 3R issue (reduce, reuse, recycle), no plastic day, and earth hour. The impacts of green advertising on green lifestyle and green products is still low, even though this issue is essential for companies to achieve green advertising implementation [14]. The essence of green advertising is a campaign on environmentally friendly products which support sustainability [15]. The concept of sustainability is undoubtedly considered necessary by various parties, such as the government, companies, and society [16]. The education of advertising seems to involve environmental issues in green advertising [17]. Green advertising appears to change customer behavior who cares about the environment. Indonesian government starts to implement the sustainability concept, which was started in 2012 through a regional regulation on Green Building in Jakarta [18]. As the government concern about the environment, it has become a part of green advertising which has been carried out by the government, to serve public service advertisements about the global warming issue [19]. The regulations issued by the government certainly have an impact on marketing strategy whereby companies tackle environmental issues through the concept of green advertising [20]. The characteristics of green advertising are difference with the advertising concept in general; because companies has a goal towards the image and reputation on social responsibility [21]. Hence, companies prioritize green advertising concept, not only for educating environmental-friendly products but also strengthening the company's image and reputation.

Realizing the importance on reviewing the implementation issue of green advertising in Indonesia and its impact on customer behavior, this study focuses on factor analysis that forms green advertising performance from a customer's perspective. This study intends to put forward the green advertising concept, so that it can be references by companies to campaign environmental issues, through symbols or images that are valuable to society towards sustainability concept.

2. Literature Review

2.1. Green Customer Behavior

Green customer behavior refers to customer behavior in using healthy, environmentally friendly products, and it can protect environmental sustainability [22]. Green customer behavior has a level of concern; the higher is the extraordinary impact on loyal behavior for all the environmental issues [23] and trying to recommend to others [24]. The customer's awareness of the environment prioritizes green products and campaigns for healthy lifestyles [25]. However, green customer behavior is not easy to develop [26]; it is influence by the internal situation of customers such as knowledge and self-awareness [27], and external situation of customers such as the environment [28]. Environmental factor has an important role [29] because it has greater level of interaction with customers.

2.2. Green Customer Behavior

Technological developments and environmental issues provide a new perspective for companies in marketing strategies through advertising media, by adopting green advertising, both offline and online [30]. Due to stiff competition, companies have started to find more creative advertising alternatives through unexpected places, unconventional methods, or unusual communication delivery [31]. It seems clear that the company's efforts are to provide awareness through advertising media, which is easy to remember and provides value for customers and the company [32]. Green advertising is believed to be a strategy that also provides opportunities to increase company's value both from the viewpoint of the product and its image [33]. It considers that green advertising has a concept that is not much different from advertising in general. However, environmental issues provide other opportunities that can be interpreted by a customer today [7]. Media in green advertising is delivered online, like social media or the internet, and offline like newspapers or billboards [34]. The previous concept states that "green advertising are advertisements that promote products, services, ideas or organizations' ability to help or reduce environmental harm" [5]. There are two elements discussed in green advertising, namely education on products or services and a positive impact on the environment [1]. The implementation of green advertising for companies is considered successful if it can provide a company's environmental image. At the same time, customers are assessed through understanding and practicing green living [7].

Green advertising is genuinely delivered by companies or the government to increase customer awareness of the environment [20]. It is undoubtedly in line with government and companies' views, which is trying to deal with the issue of "global warming" and environmental sustainability [35]. Customer care is captured in a consistent attitude that considers good or bad towards a product in the environment to recommend it to others. It seems clear that green advertising is considered effective if it can influence customers' perceptions and customer behavior in the environment [17]. In the previous studies, it has been known that the impact of green advertising on customer behavior such as concern [5], perception [17], attitude [12] to company's image [36]. However, the essential green advertising concept is the consequence of growing customer awareness of the environment [20]. There are many green marketing strategy research indicated the impact of environmental knowledge and the awareness on customer behavior towards the environment [37]. Several media become customer's references in examining the concept of green advertising, such as television, website, media social, radio, newspaper or magazine, billboards, banner dan brochure [5]. However, each media certainly provides a different level of preference; it depends on the level of persuasion given. In the end, the concept of green advertising needs to meet three main criteria, namely explicit or implicit about the correlation between products and environment [12], promoting a green lifestyle with or without products [38], and it explains company image that cares to environment [20].

2.3. Measurements of Green Advertising

Green advertising's implementation contains two prominent elements; informational claims and effective claims [3]. Informational claims are related to the use of environmentally friendly products advertised, while effective claims are the experiences relate to the environment. Indeed, informational and effective claims provide a positive view of customers in assessing green products [12]. There are many criterias in assessing and evaluating green advertising; several previous studies have explained that there is no definite measure that can represent green advertising [3]. All criteria depend on the objectives of green

advertising and customer's goals that determine the success or the failure of advertising done [2], [5], [11]. Some experts' opinions explained the measurement of green advertising. Firstly, it starts with green impact, which is the importance of advertising media that takes to environmental issues into a biophysical environment, green lifestyle, and an image of environmental responsibility [21]. Secondly is a green message, where advertising is assumed necessary to give a clear message related to ecological, environmental sustainability, or nature-friendly messages [39]. The third is a green theme, where advertising needs to provide an attractive theme to be enjoyed by customers on green products that are pleasant, convincing, believable, favorable, and goods [12].

Fourthly is green emotions, where advertising can conveye the emotional values for customers in terms of environment-protection emotion [2], [40]. Customer emotion in advertising is related to moral emotion, social emotion, and ecological fear related to climate change [2]. The fifth is related to customer's experience; it is undoubtedly essential; it is related to the green experience. Advertising is assumed as necessary to provide an experience that is assessed from the perspective of knowledge, perceived comfort, and information obtained by customers [41]. Next is assessed from green interaction related to the level of interaction that customers will feel on advertising, such as appeal, issue proximity, and environmental consciousness [42]. Finally, the measurement based on the previous studies is assessed to green claims. This measure puts forward the recognition of environmental friendly products that can meet customers' expectations in terms of degradable, recycled, recyclable, ozone friendly [43].

3. Research Methodology

The research method was conducted by surveying customers who purchased environmentally friendly products through a set of questionnaires. Customer were chosen from products categories that is convenient to customers, such as food and beverages. Data were carried out through online questionnaire among customer in West Java Province. The answers had been determined through Likert Scale approach, from "1" for strongly disagree and "7" for strongly agree. The questionnaire was distributed within three months, from August to October 2020, with a target of 300 respondents. This research was also included in experimental research where the respondents were given a treatment, which was the knowledge related to green advertising at the beginning of the questionnaire to find out their views regarding green advertising in Indonesia.

The data from respondents were processed through the Confirmatory Factor Analysis (CFA) technique; it intended to find-out the factors that determine the creation (or development?) of green advertising proposed by the research model. Meanwhile, the analysis tools used were SmartPLS, considering the ease of analyzing CFA on data below 300. Based on the previous theory study, several elements would be studied in determining green advertising, such as green impact, green message, green theme, green emotion, green experience, green interaction, and green claim. Each dimension was measured by an indicator as shown in Figure 1. Data analysis stages were started from data tabulation, research model fit test, and research hypothesis test. Considering that this research used the CFA approach, only a fit model test through Outer Model would be conducted. It was tested for convergent validity, composite reability, average variance extracted, and discriminant validity [44], [45]. Meanwhile, the research hypothesis test was conducted by evaluating the value of Kaiser-Mayer-Olkin Measure of Sampling Adequacy (KMO MSA), where it must be more than 0.5, and the value of Bartlett's Test of Sphericity (Sig.) was smaller than 0,05 [46]. The final objective of the analysis was to find the determinant factors to develop green advertising that provide customers' value of customers'concern for environmentally friendly products.

From previous research studies, it appeared that several measurements can be assessed from green advertising. However, all of them have one goal: to increase customer awareness of green advertising implementation. In this study, the measurements that have been tested,were green impact, green message, green theme, green emotion, green experience, green interaction, and green claim [2], [21], [39], [41], [43], [47]. The essence of some of these measurements provide the same opportunity as a determining factor in assessing green advertising; before the Confirmatory Factor Analysis (CFA) is carried out, the assumptions are conveyed in the form of research hypothesis based on the CFA model as follows.

Hypothesis 1 (H1) Green impact is a dimension that can developed green advertising.
Hypothesis 2 (H2) Green message is a dimension that can developed green advertising.
Hypothesis 3 (H3) Green theme is a dimension that can developed green advertising.
Hypothesis 4 (H4) Green emotion is a dimension that can developed green advertising.
Hypothesis 5 (H5) Green experience is a dimension that can developed green advertising.
Hypothesis 6 (H6) Green interaction is a dimension that can developed green advertising.
Hypothesis 7 (H7) Green claim is a dimension that can developed green advertising.

4. Result and Discussions

Confirmatory Factor Analysis (CFA) research relates to green advertising; it starts by distributing an online questionnaire for three months (August, September, October).

Data from the questionnaire spread to 215 respondents who filled in the data correctly, then data was tabulated, and the research model was tested through SmartPLS. Data analysis begins with the research instrument test, research hypothesis test, and analysis of Confirmatory Factor Analysis test result.

4.1. Validity and Reliability Test

Before conducting data analysis through CFA, validity, and reliability tests were examined. Considering that analysis is carried out through CFA, the tests are conducted only using the outer model test for convergent validity, composite reliability, average variance extracted, discriminant validity, and outer weight. If all the outer model test results are adequate, it is stated to be fit, and a CFA study can be carried out.

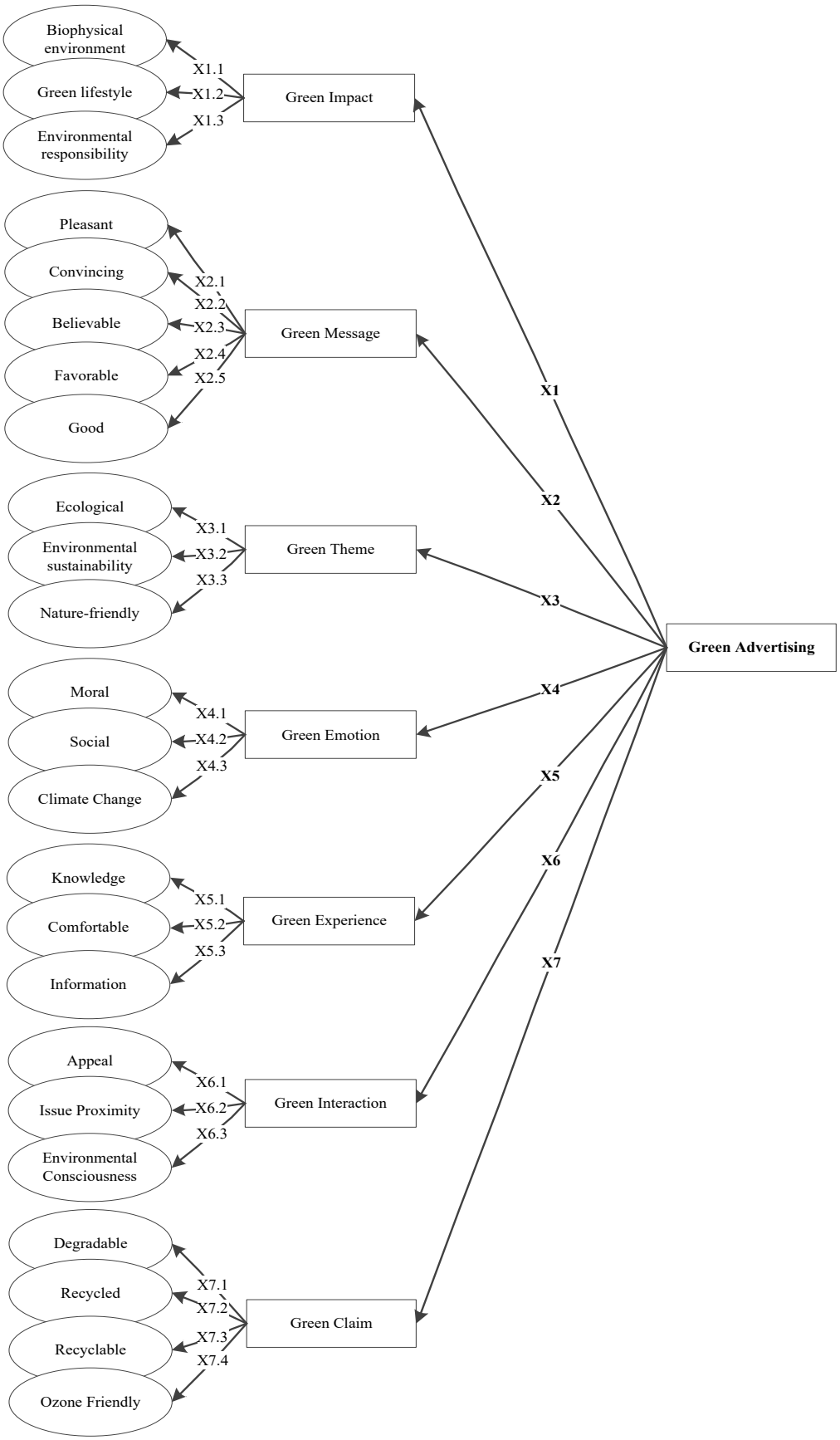

Figure 1: CFA Model

Convergent validity test is assessed by evaluating the correlation of outer loading results, which is more than 0.50 for the correlation. Furthermore, the discriminant validity test shows whether the measured variable has acceptable reliability. Discriminant validity has known through the evaluation of the composite reliability value, which must be above 0.8. The next test is the Average Variance Extracted (AVE) value, which is stated to be fair, and it fulfills the criteria when the value is more significant than 0.5. The next evaluation studied Cronbach's Alpha's value, which is one of the recommended discriminant validity measures to have a value above 0.7. The final test is carried out the outer weight, which is stated to fulfill the requirements if the outer weight value is above 0.20. The results of the first outer model test are summarized in Table 1, which indicated that from all the previous tests, composite reliability, AVE, and discriminant validity are fulfill the requirements.

The second outer model test results which related to outer weight are summarized in Table 2, which evaluation of sample original value is above 0,20. It is stated to be fit, or it means that it fulfills the requirements. Finally, the results of the outer model test reviewed from convergent validity, where the results are summarized in Table 3 with all of the outer loading value are accepted because the correlation value is above 0.50. Based on all of the test results of the outer model, it can be stated that the research instrument can be accepted, and it can be analyzed further for CFA.

Tabel 1: Construct Validity and Reliability

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Green Impact	0,924	0,926	0,939	0,688
Green Message	0,843	0,844	0,905	0,761
Green Theme	0,825	0,827	0,878	0,590
Green Emotion	0,796	0,796	0,880	0,710
Green Experience	0,747	0,747	0,856	0,665
Green Interaction	0,775	0,784	0,870	0,691
Green Claim	0,773	0,785	0,868	0,688

Tabel 2: Outer Weight Values

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
Biophysical Environment	0,368	0,369	0,017	21,769	0,000
Green Lifestyle	0,387	0,387	0,016	24,088	0,000
Environmental Responsibility	0,391	0,391	0,016	24,600	0,000
Pleasant	0,242	0,242	0,015	16,551	0,000
Convincing	0,276	0,276	0,016	17,230	0,000
Believable	0,270	0,271	0,014	18,720	0,000
Favorable	0,254	0,253	0,017	15,269	0,000
Good	0,259	0,259	0,016	15,899	0,000
Ecological	0,400	0,401	0,015	27,331	0,000
Environmental Sustainability	0,401	0,400	0,017	22,947	0,000
Nature-Friendly	0,386	0,386	0,015	25,172	0,000
Moral	0,421	0,420	0,022	18,967	0,000
Social	0,393	0,395	0,015	26,166	0,000
Climate Change	0,413	0,414	0,021	19,750	0,000
Knowledge	0,440	0,440	0,017	25,158	0,000
Comfortable	0,375	0,374	0,017	22,605	0,000
Information	0,386	0,386	0,017	23,110	0,000
Appeal	0,440	0,442	0,020	22,460	0,000
Issue Proximity	0,345	0,345	0,022	15,632	0,000
Environmental Consciousness	0,416	0,417	0,021	20,084	0,000
Degradable	0,256	0,256	0,016	16,240	0,000
Recycled	0,303	0,304	0,015	19,858	0,000
Recyclable	0,304	0,304	0,011	26,755	0,000
Ozon Friendly	0,308	0,308	0,014	21,757	0,000

Tabel 3: Outer Loading Values

Instruments	Green Impact	Green Message	Green Theme	Green Emotion	Green Experience	Green Interaction	Green Claim
Biophysical Environment	0,848						
Green Lifestyle	0,887						
Environmental Responsibility	0,882						
Pleasant		0,748					
Convincing		0,835					
Believable		0,820					
Favorable		0,721					
Good		0,708					
Ecological			0,848				
Environmental Sustainability			0,858				
Nature-Friendly			0,821				
Moral				0,826			
Social				0,835			
Climate Change				0,784			
Knowledge					0,878		
Comfortable					0,775		
Information					0,838		
Appeal						0,862	
Issue Proximity						0,779	
Environmental Consciousness						0,845	
Degradable							0,793
Recycled							0,890
Recyclable							0,860
Ozon Friendly							0,862

Table 4: Values of KMO

Hypotheses		KMO	Sig.	Result
Green Impact ← Green Advertising	H1	0,772	0,000	Accepted
Green Message ← Green Advertising	H2	0,791	0,000	Accepted
Green Theme ← Green Advertising	H3	0,705	0,000	Accepted
Green Emotion ← Green Advertising	H4	0,674	0,000	Accepted
Green Experience ← Green Advertising	H5	0,674	0,000	Accepted
Green Interaction ← Green Advertising	H6	0,694	0,000	Accepted
Green Claim ← Green Advertising	H7	0,826	0,000	Accepted

4.2. Factor Analysis of Green Advertising

This research focuses on green advertising, which is assessed from several criteria, including green impact, green message, green theme, green emotion, green experience, green interaction, and green claim. Based on the result in Table 3, it showed that all outer-loading values are accepted; with the value above 0.70. Outer loading values explained the level of closeness between the indicator and its dimensions because the determining indicator is better when it close to 1. The result indicated that several factors supported the creation of dimensions on green advertising. The first dimension is green impact with a sequence of determinants, which starts from green lifestyle, environmental responsibility to the biophysical environment. The green impact is a dimension for green advertising and can motivate customers who accept advertising [48]. The first measurement, which becomes a customer's attention, is green lifestyle, where customers assume that green advertising is expected to provide a new lifestyle for healthier customers. The next dimension is green message; several supporting indicators with a sequence are convincing, believable, pleasant, favorable, and goods. Green messages can be a dimension that forms green advertising; it considers that advertising is full of messages; customers will receive advertisements recipients [39]. Customers prioritize convincing message or giving confidence because the advertisement is trustworthy and not an imaginary advertisement. Another dimension that becomes the determining factor of green advertising is green theme with indicators formed from environmental, ecological sustainability, and nature friendly. A green theme is related to a theme in online or offline advertising, considering that a theme will stimulate customers to understand the meaning of advertising [12]. In this case, a green theme that becomes the primary concern of customers is environmental sustainability issue. This is because the themes have more impact on customers' understanding in conveying the advertisement.

The next dimension is green emotion, which is formed from several indicators, such as climate change, social, and moral.

Green emotion is considered as dimension that represent green advertising related to customers' emotional level when look at the advertisement. These emotions are positively natural-friendly, and aim to believe more in advertising behind green advertising [2]. Based on loading factor value survey, it has been revealed that the size of climate change is the most important indicator that can change customers' emotional value because green advertising relates indirectly to the issue of climate change. Green advertising lead to the assumption of customers involvement; which is stated in the green experience dimension [7]. Green experience is assessed from information, knowledge, and comfortable. Customers certainly hope that in assessing green advertising, they can improve their experience, and this experience is considered essential when it comes to the information they need. The next dimension that becomes the determining factor for green advertising is green interaction; it is formed by several indicators, such as appeal, environmental consciousness, and proximity issues. Green interaction is related to customers' interactions with the advertisements [42]; the outer loading appeal stated that it is the most influencing indicators. It means that green advertising will be able to invite interaction from customers if the advertisement is attractive. It is the reason why people said that to create content of green advertising is quite challenging because it requires special attention that relates to the environment. The last dimension is related to green claims, which consist of recycled, ozone friendly, recyclable, and degradable. It means that green claims relate to customers' recognition for the advertisements [43]. This recognition is considered as the most important recognition, because it need to ensure environmental-friendly product to be easy recycled.

A hypothesis test surely to tests the analysis results of determinants factors of green advertising; it was intended to emphasize that all the dimensions have been determined, and it can be a measurement for green advertising. The hypothesis test results are conducted by evaluating the value of KMO presented in Table 4. All "accepted" dimensions can be dimensions for green advertising. It considers that the value of KMO is above 0.5, and the value of Bartlett's Test of Sphericity (Sig.) is smaller than 0,05. Therefore, the result stated that the indicator factors which consist of green impact, green message, green theme, green emotion, green experience, green interaction, and green claim can develop green advertising.

4.3. Model of CFA Green Advertising

In the research finding of the analysis factor, there are seven dimensions of green advertising; green impact, green message, green theme, green emotion, green experience, green interaction, and green claim. However, these dimensions certainly have a different standard value informing to green advertising assessed by customers. Therefore, to determine the highest and lowest standard in green advertising, value extractions based on commonalities process [49] has been conducted, as illustrated in Figure 2.

Based on Figure 2, it is clear that the highest extraction value is green experience, and the lowest extraction value is green impact. The extraction value determines the impact's size of dimensions in determining green advertising. The findings show a composition of dimensions that can develop green advertising, which is started from experience, theme, message, claim, emotion, and interaction to impact. The dimensions need to be conducted priority scale by companies if companies decided to adjust green marketing to green advertising. These research findings explain the importance of adjusting green advertising implementation as part of marketing strategy.

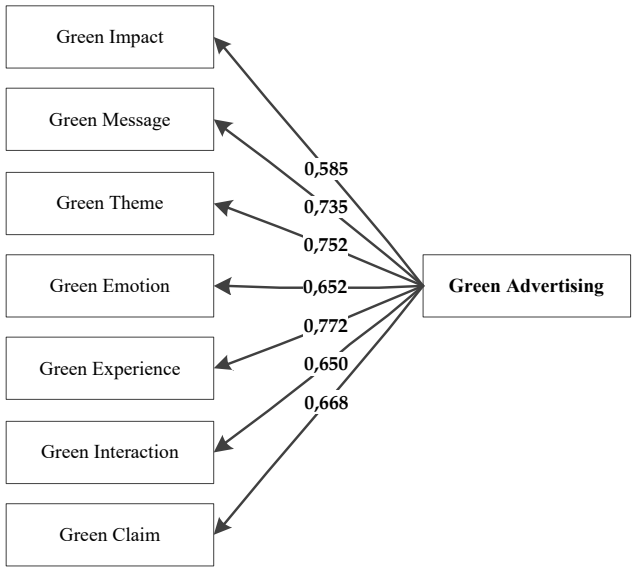

Figure 2: Model of Green Advertising

This study focuses on the behavior of customer who have purchased environmentally friendly products in Indonesia (West Java), which means that companies can utilise the model of green advertising (Figure 2) in promoting pure environmentally friendly products. All green advertising dimensions have meaningful content, so it would be better to develop green advertising. However, if the dimensions are to be reduced, it is advisable to start from the dimensions that have the lowest impact in developing green advertising. It means that the green advertising model's use of dimensions is adjusted to dimensional load in forming green advertising. The goal of green advertising can be achieved, namely product education that is friendly to the environment. The finding of this research can provide input for the government in advertising policies, for company in implementing green marketing and for society as customer who needs to get information related to a sustainable environment.

4.4. Customer Perceived of Green Advertising

Green advertising can give impacts on customer behavior by providing the assumptions and responses to environmental sustainability [1], [5]. In this case, customers of products and services offered by the company certainly need to understand the advantages and disadvantages of products they will choose, particularly for products that have a positive impact on the environment. Therefore, it is essential for company to implement green advertising. However, the implementation of green advertising needs to consider several dimensions which can develop the right customer's perception. In this study, a series of dimensions has been stated, namely: experience, theme, message, claim, emotion, and interaction. These findings are based on customers' assessment in evaluating green advertising received by them until now, and it refers to the evaluation on

environmentally friendly products. Based on green advertising results, it can be argued that a customer's experience of green products is controls by the customer perceived value of green advertising; the theme of the conveyed advertisement; the message of the conveyed advertisement; the advertisement claim which can change customer's confidence; customer emotion is positive after seeing the advertisements; customer interaction is optimistic after seeing the advertisements; and the impact of advertising which motivates to customers to live a healthy life.

The research findings depicted in Figure 2 can be implemented by companies to educate customer on environmentally friendly products and the government in educating the importance of environmental sustainability to society. However, the model of green advertising is not suitable when used in educating conventional products or is not purely environmentally friendly because the dimensions used in this study focused on green products and the selected consumers have an environmentally friendly concern. So it is necessary to consider green advertising that companies use is not only for environmental issues, but also for the products created. This research findings explained the importance of understanding customer behavior in supporting the implementation of marketing strategies; mainly, it takes environmental issues as green advertising. There is essential information for stakeholders such as the government, companies, and society in promoting green advertising.

5. Conclusions

This study aims to analyze the determining factors in deciding green advertising, in which there are several measurements have been presented by the previous studies. This study provides the appropriate measurement for green advertising which can be utilized to educate customers. Seven dimensions were tested in determining green advertising, namely: experience, theme, message, claim, emotion, interaction to impact. The implementation of green advertising has impacted customers' points of view; and it considered several customers' attention. Customers' attention means experience, which consist of information, knowledge, and comfort issues. A model of green advertising through Confirmatory Factor Analysis was developed in this research. Through this model, it can provide some input to the government in evaluating the policies to deal with "global warming" issues, as well as to companies in implementing green marketing.

This research, however, has certain limitations. It applied CFA based on each dimension and does not study the impact of green advertising implementation on customer behavior, for instance customer care. Therefore, future research should emphasizes on the utilization of exploratory factor analysis (EFA) and the impact of the study on customer behavior. In addition, this research does not examine the technology used in green advertising, so it is recommended that further research to examine the technical support in green advertising, taking into consideration that that the advertising model is utilizing electronic and digital media, which are related to the latest technology.

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The Impact of eLearning as a Knowledge Management Tool in Organizational Performance

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ABSTRACT

This paper aims to understand the impact of eLearning capabilities on organizational performance. It also addresses the obstacles of organizational learning using eLearning methods and highlighting some emerging trends and technologies that will impact the eLearning experience in organizations. It examines a brief history of knowledge management and how it is related to learning, organizational learning, and performance. It also explores different eLearning technologies and trends. A systematic literature review was used to examine previous papers between 2016–2020. Results show eLearning can impact organizational performance in many ways, and human factors can be one of the most challenging obstacles in deploying eLearning solutions in organizations, and many emerging eLearning trends were explored including open educational resources, gamification, flipped classrooms, and many others.

1. Introduction

The fast-paced growth of information communication and technology is changing the world we live in into a knowledge-based society [1–3]. Within the context of the fourth industrial revolution and the knowledge-based economy, knowledge and learning systems play an important role in countries' competitiveness and organizational performance (OP).

Knowledge capturing has become a strategic priority for many countries as an essential asset [4–8], especially if they want to remain competitive, driven by rapid development in knowledge creation and high demand for skilled human capital [9–12]. In the past, countries and organizations could achieve that by traditional educational and vocational training systems; however, the new era requires faster and shorter innovation cycles to remain innovative, which increases the need for continuous skilled and trained human capital with constant knowledge updates and skillsets.

The current workforce is transforming the traditional "single-skilled personnel to multi-skilled employees" who can manage multi-tasks under one job title. Such a goal will be possible only through new disruptive learning models and life-long learning (LLL) [13]. One of the knowledge-capturing and sharing tools is eLearning, where organizations and educational institutes can conduct training via electronic media via the internet. The COVID-19 pandemic has forced many institutes and organizations to carry out their training and education activities via eLearning tools [14,15]. These activities revealed some limitations in current eLearning practices such as quality of interaction, lack of natural discussions, and limited nonverbal communication [16]. The reason can be anything, ranging from the use of old-fashioned eLearning practices to poor content and connection quality.

Alternatively, the use of technology-enhanced learning (TEL) via mobile is changing the learning process for many. Language learning apps, for example, are impacting how learning is taking place. A recent study concluded that Duolingo is fostering vocabulary and grammar development [17]. Other fun and engaging examples include fitness training apps from Adidas and Nike and musical instrument training apps like Yousician. TEL is becoming one of the trending topics in computer science as it utilizes the use of computers, mobile, software and apps to assist learning [6].

The advantage of TEL is that it guarantees learning continuity in different circumstances such as during pandemics, natural

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disasters, extreme weather conditions or for learners with disabilities. It frees the instructor from creating redundant lessons and devotes more time to developing quality learning materials. It also allows learners to engage in active and independent play-based learning and life-long learning [18].

Organizations need to encourage LLL via on-the-job training and eLearning methods. These learning methods will ensure that the current workforce is well equipped with the latest skills. Before knowledge is transformed into learning materials (eLearning), it is necessary to manage such knowledge first. Learning is an essential part of the Knowledge Management's (KM) life cycle, which complements the process of establishing, distributing, implementing, and managing the knowledge and information of an organization. It refers to a multidisciplinary approach to achieve organizational objectives by making the best use of knowledge. The most recent studies uncover the massive significance of presenting KM insights into eLearning frameworks. KM is believed to encourage an eLearning framework, where the joint effort between eLearning and KM will provide the single objective of hierarchical learning [19].

In this paper, we have included papers that are relevant to the role of KM, eLearning, and OP. We have reported a systematic review of the advances in eLearning in KM in response to OP. The objective is to provide overviews of the research studies within this field, how these concepts interact with each other, the main obstacles, and the recent emerging trends. More specifically, we have asked the following questions:

Table 1: Research question.

#	Research question
RQ1	How is eLearning capabilities in KM impacting OP?
RQ2	What are the challenges in implementing eLearning in organizations?
RQ3	What are some of the emerging trends and technologies in eLearning?

2. Literature Review

This section will highlight the recent contribution that focuses on the subject of this study, including the discussion of the latest practices related to KM, eLearning, training technologies, organizational learning, and performance.

2.1. Origin of KM

KM started within the management consulting community. They had realized how the internal networks in their organization is a vital tool to share and access information with their units, especially when these units were scattered in different geographical locations. While these consulting groups were working on facilitating their network to their use, they have gained some knowledge and recognized some good practices, such as developing and building these tools, expertise locators, lesson-learned databases, and designing dashboards.

They have realized the newly acquired expertise can be packaged, marketed, and sold to other similar entities, who might have multiple locations and experienced the same challenges. However, the new product needed a name. It seemed the term "Knowledge Management" had appeared in this context for the first time in 1987. The KM term was spotted in an internal study in McKinsey on how to handle and utilize their information.

In 1993, the knowledge management went public at a conference organized by Ernst and Young. A young man at Ernst and Young came up with one of the first classic one-line definitions of KM. Tom Davenport defined KM as the process of capturing, distributing, and effectively using knowledge [20].

In 1998, the authors of [21] worked on a revised definition. They described KM as the activities related to utilizing and developing organization knowledge assets in line with organizational objectives. Early work by [22] in 2005 was among the first to link KM with innovation, as he defined KM as the purposeful and systemic coordination of an organization's individuals, technology, process, and structure to create values via reuse and innovation [23].

There were many models aroused around coordination between people, process, technology, and organization structure, including Wigg Model (1993), Zack Model (1996), Bukowitz and William Model (2000), and McElroy Model (2003). The following table explains the KM lifecycle steps, according to the four proposed models [24].

Table 2: KM lifecycle steps according to the four proposed models.

WIGG 1993	**Zack 1996**	**Bukowitz & Williams 2000**	**McElroy 2003**
Creation	Acquisition	Get	Learning
Sourcing	Refinement	Use	Validation
Compilation	Store	Learn	Acquisition
Transformation	Distribution	Contribute	Integration

In [24], the author summarizes the steps in seven steps: Identity, Create, Store, Share, Use and Learn. For this review, the focus has been on the learning aspect and knowledge sharing with more details.

2.2. KM & learning

A study by [25] explained how KM and learning work together. The knowledge assets used and shared in the past could be the foundation for creating new and improving current ones. In situations where experts provide a certain understanding in a context, the employees gain and learn a new experience and apply that knowledge to their workplace. If the knowledge resources have been found insufficient or incomplete, the researcher goes back to the identity/creation phase where additional resources are created based on the gaps found. This repeatable process creates double-loop learning. Some of the activities that assist the learning stage are benchmarking, best practices, lessons learned, and knowledge gap analysis. Technological applications and examples can be found in learning management and help desk systems [24].

2.3. KM in organizations

In addition to organizations' ability to learn and unlearn, collective knowledge is an essential asset in improving OP. It would also increase profitability, which will eventually create and maintain a competitive advantage. A study by [26] defines

organizational learning (OL) as using a purposeful learning process on individual, group, and system levels while changing the organization to satisfy its stakeholders. Scholars of [27] describe organizational learning as a social process where individuals engage in practices and speeches that reproduce the OL and expand it simultaneously.

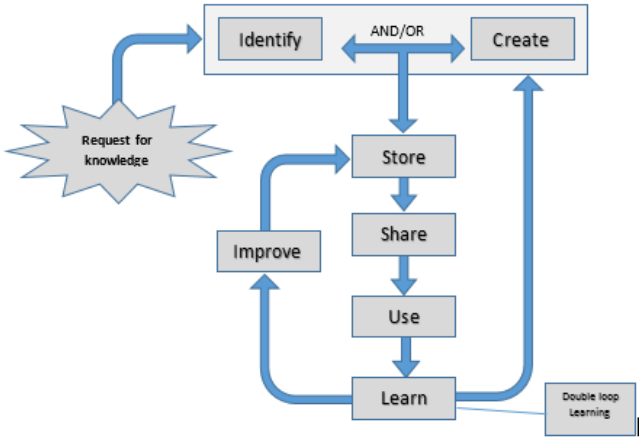

Figure 1: The KM Cycle (KMC) Model [24]

Four major vital areas were identified in [12]. These areas are the business drivers for the increased importance of KM in the organization today.

1. *Globalization of business:* The organization today is more global, multisite, multilingual, and multicultural.
2. *Leaner organizations:* Productivity is increasing faster, but it also needs to be done smarter as workers in KM are adapting to an increasing work pace and load.
3. *Organization amnesia:* Workforces are becoming mobile, which creates a challenge in sustaining knowledge in the organization and requires continuous learning. Employees are no longer expected to spend their entire lives in the same organization.
4. *Technology advancement:* People are connected seamlessly. The connections are not only ubiquitous but have radically changed expectations. Workers are expected to be "on" all the time, and response turnarounds are now measured by minutes, not weeks or even days [24].

One of the key challenges organizations face is the uncertainty of how exactly learning and KM impact OP. A dilemma that might create an ambiguity among leaders is how to optimize resources from KM. KM has no choice but to demonstrate how exactly they add value to the stakeholder [28]. A study by [29] examined the impact of KM on organizational learning, using OL in a mediating role. Results taken from 150 random samples show a close relationship between KM and OP. A critical insight is that OL is playing a mediating role between OP and KM. The study also revealed a positive relationship between emotional intelligence and OP.

In contrast, [30] investigated the effects of KM strategy and the effects of OL on OP. This study was conducted using a 5-point Likert-scale questionnaire on all levels of management in oil cooperation. The data collected from 161 managers confirmed that KM strategy is one of the preconditions and impactful factors regarding OP and innovation. In contrast, OL does not seem to have correlated with organizational innovation.

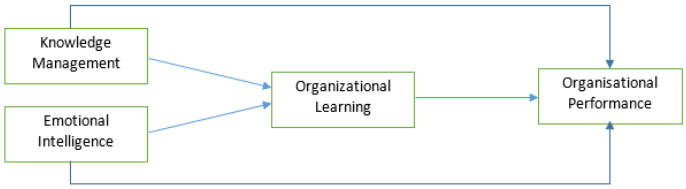

Figure 2: Relation between KM and OP [29].

2.4. eLearning

If we want to take a closer look at learning and training in the organization today, technology will be found as the driving force in workplace training. ATD's state of the industry report (2018) indicated that eLearning accounted for 40 percent of the formal learning hours used in 2017 [31]. The commonly known eLearning definition usually describes the activities of conducting learning using information and communication technologies. The authors of [32] identified that the most important remarkable milestones in learning are the evolution from distance learning to electronic learning to mobile learning. These three stages are in line with the impact of the Industrial Revolution in the eighteenth and nineteenth centuries and the Electronic Revolution in the last decade of the twentieth century [32].

Recent studies suggest that Massive Online Open Courses (MOOCs) will play a prominent role in organizational learning, provided these courses are relevant to the workplace and integrated effectively into the current training systems [33]. For many leaders and human resources trainers, eLearning is an easy way to provide workplace gamification content. The challenge remains that most training courses are theoretical and based on college courses, and they might not meet the corporate training version yet (except Udemy). However, a few work particularly with corporations to tailor-make their business knowledge into user-friendly courses, similar to ones we can identify with MOOCs platforms.

2.5. Computer-Assisted Learning

Computer-Assisted Learning (CAL) is one of the top 5 emerging trends in computer science in recent years [18]. This term can also be referring to Computer-Based Instruction (CBI), Computer-Aided Learning (CAL), or Computer-Aided Instruction (CAI) [34]. CAL can be defined as "learning that supplements regular classroom activities with computer activities during or surrounding classroom time" [35]. Apps are one well-known form of CAL applications. The authors of [36] found that educational apps can have added values to the learning process not available in the conventional eLearning tool, including repetitions, swift feedback, fun, creative tools, variety of methods, and pronunciation.

For this review, we can simply define CAL as "the learning procedures and environments facilitated through computers" [34]. The application of CAL is unlimited. One example of CAL applications can be seen in the medical field, which has recently become "a truth universally acknowledged" as a proven way to enhance the student learning process. In contrast, some instructors and trainers may lack the basic computer science skills needed to

fully utilize technology in learning. Lacking key ICT skills might be one of the obstacles that limit the use of TEL tools [36].

2.6. Technology-Enhanced Learning

The emerging term Technology-Enhanced Learning (TEL) is a broad category that does not have a particular definition. It can refer to any type of technology that enhances the learning experience [37]. "Mentimeter" is an example of an interactive presentation platform that utilizes the capabilities of TEL. The trainer can build an interactive presentation; collect polls, data, and opinions from learners; and export the insights, data, and trends from participants' input. Media Technology and Interaction Design have identified many research areas around TEL, including learning analytics, the interplay of learning design and technology, design-based research, computer-supported collaborative learning, blended learning, sustainable design, and visualization for TEL-related issues [38]. A study by [39] provided an interesting application in eLearning. The Georgia Institute of Technology in the United States provided some of their online courses using virtual teaching assistants (TAs). The chatbot was developed using IBM *Watson*; the TAs can reply to student questions without informing the learner that they are artificial intelligence agents.

2.7. eLearning in Information Technology (IT) Companies

When it comes to technology companies and IT organizations, one can assume they are already ahead of others when it comes to their eLearning capabilities. There is little known about how they transform knowledge internally. One of the interesting findings that high-tech companies like Microsoft, Google, IBM, Cisco, Canon and Microsystems are using gamification capabilities to motivate and train their people. Canon technicians are learning how to fix and repair by literally dragging and dropping parts virtually, while Cisco has a platform called MyPlanNet, where employees play the role of a company's manager. Additionally, IBM developed a game simulation that allows employees to run an entire city [40].

Another common practice among technology companies is to share their online training materials externally. In other words, they focus on training individuals before they hire them, particularly because high-tech companies require highly skilled human resources already trained in their preferred way of working. For example, IBM- and Google-certified specializations can be found on eLearning platforms like Coursera, Microsoft courses, Edx and Udacity. This practice not only cuts training costs for IT organizations but may also become an additional profit centre as they license these certificates. In addition, companies can access a pool of talented full-stack programmers when needed.

2.8. Life-long Learning and eLearning

Life-long learning (LLL) sometimes gets confused with adult learning. LLL is a process where individuals seek learning opportunities to develop their knowledge, skills and life (Richardson, 1978 in Mouzakitis & Tuncay, 2011). Individuals who have an interest in LLL have a continuous ambition to learn and are responsible for their self-learning. According to the European Commission (briefing paper 20, 2001), LLL has become a targeted objective for learning policies at the national and international levels in recent years. In [41], the author conducted empirical research on 138 employees and found that seven out of ten employees prefer eLearning course delivery over classroom attendance. These data support how eLearning should play a vital role in executing lifelong training, especially for employees between 55 and 64 years old in all sectors.

3. Methodology

In an attempt to follow a preferred reporting items for systematic reviews and meta-analyses (PRISMA), research should provide an explicit statement and form questions including participants, interventions, comparisons, outcomes, and study design (PICOS) [42]. Therefore, the research questions (Table 1) have been formed based on PICOS principles. The following detailed systematic review is based on results from research papers obtained in different online journals and databases that focus on eLearning, KM, and OP, in addition to CAL.

3.1. Data sources and Search Strategies

Different articles were found to match the searching criteria. In particular, 211 materials were found in credible online journals. All the results were found using WorldCat.org, Google Scholar and Crossref databases, as shown in Figure 3. The searching algorithms used included the presence of the required elements in the research objective; additionally, the exclusion aided to sort out the sources which were undesirable, and no organizational context was side-lined, leaving only the required data. The following keywords have been used to locate information from the journal kw: ("computer-assisted education" OR "computer-assisted learning" OR "computer-assisted training" AND "knowledge management" AND "computer science") AND kw: ("e-learning" OR "eLearning" OR "online learning") AND (yr: 2016–2020). Additional keywords used to refine the search are "eLearning" AND "organizational performance" OR "organizational performance". Table 3 gives more insights on the inclusion and exclusion criteria.

Table 3: Inclusion and exclusion criteria

Inclusion	Exclusion
Articles published in 2016 or later	Articles published before 2016
Should be related to KM methodologies, processes, or lifecycles	Related to KM or OP but not linked to eLearning
Should be related to computer-assisted learning or techniques	Related to eLearning but not linked to KM or OP
Should have five or more citations	Has fewer than five citations
Papers are in English	Papers are not in English
Articles	Books or book chapters

3.2. Challenges faced

There is no one clear definition of the field of computer-assisted learning, making it challenging to locate all the research about it and its relation to the eLearning and KM cycle. Some related terms are computer-assisted education, computer-assisted instruction and TEL. The category of TEL may be too broad or have no direct relation with eLearning and OP yet.

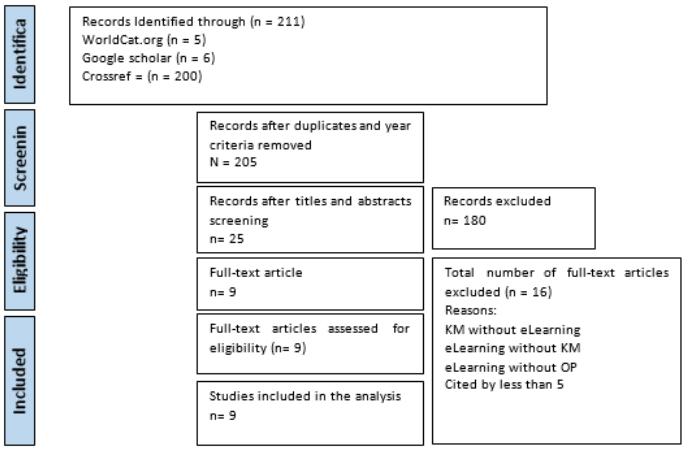

Figure 3: Research PRISMA model [43]

4. Results

The following is the result of reviewing the shortlisted nine research articles published between 2016 and 2020 on the impact of KM strategy and learning capabilities on OP.

4.1. RQ1. How are eLearning capabilities in KM impacting OP?

Previous studies mentioned that organizational eLearning capabilities in their KM context could enhance OP in many ways. Table 4 summarizes the main findings of the analysed KM researches in the context of eLearning and OL.

The finding revealed the many ways eLearning capabilities can impact OP. eLearning is a scalable tool that can increase individuals' competency levels on large scales. Every single individual can contribute to their organizational competitiveness, accelerate innovation rate and ultimately achieve a knowledge-based economy for their societies [19]. eLearning can also cut training and travel costs and ensure consistent training for all, increasing the quality and ensuring everyone is getting the same high-quality training [44]. Using the right eLearning capabilities can make a difference in the impact of the performance and quality result. eLearning Management Systems such as Moodle have proven to be the most effective tool in knowledge transferring compared to other distance learning tools such as email and teleconferences. Picking the right eLearning tool is essential because it increases the knowledge sharing among individuals and eventually increases performance and productivity [45]. Developing and sharing eLearning content on open platforms can also lead to gaining customer trust, attracting talent and enhancing organizational reputation. eLearning can also work as a new revenue stream for organization setting on knowledge assets [33].

Table 4: Analysis of KM research with regards to eLearning and OL.

Ref.	Purpose	methods	Finding	Country
[19]	KM and eLearning in Organisations.	Literature review	eLearning will not run alone without the KM.	Malaysia
[33]	The role of open educational resources (OER) in the eLearning movement	Literature review	Opportunities and advantages and limitation of OERs	Iran
[44]	E-Training & employees' performance.	Survey	Significant relationship between e-training (including e-training infrastructure & methods) and job performance,	Bahrain
[45]	The effectiveness of eLearning on change management and KM strategy in the organization using "Moodle".	Case Study	eLearning is the most effective method of knowledge transfer.	Canada
[46]	Study deep learning applications for developing resource for eLearning platform.	Qualitative	Deep learning enables the reusing repurposing current eLearning resources to create more personalized experience.	Saudi Arabia
[47]	How mobile learning experiences can support the co-creation of new knowledge.	Qualitative	That mobile technology is an excellent way to stimulate the social co-creation of new knowledge.	Thailand
[48]	A review of the current literature on digitally based serious games & gamification using digital tools in corporate training.	Literature review	Design principles for a game-based training methodology.	United States
[49]	The role of OL in employee engagement. The role of eLearning resources quality in bank sector.	Survey	OL positively impacts employee engagement, and eLearning resources quality partially impact employee engagement.	India
[50]	To integrate inquiry learning and KM into a flipped classroom to programming students in a higher education setting.	Quantitative	Integrating KM and inquiry-based approach into a flipped classroom can improve students' performance.	Thailand

4.2. RQ2. What are some obstacles to organisation learning using eLearning?

There are many factors that could undermine eLearning's effectiveness in any organisation. The first factor is the human factor. Some employees will resist sharing or allowing knowledge to transform because it might threaten their existence and will make them replaceable. Another factor related to human nature is the willingness to learn. Employees being in their comfort zones too long will not benefit from eLearning materials, and they might need some explanation on how eLearning can be useful for their career advancement [19]. Another human-related factor is the widespread belief that free and accessible content is worthless. The language [33] and the user interface can also be an obstacle to accessing the eLearning platform. The platform needs to be easy and straightforward to use, or the employee should be trained on it if necessary [44]. The quality source of the eLearning is also vital to ensure that useful and accurate messages are being delivered. This factor is particularly critical in some industries, such as the financial sector [49].

Content high initial development cost can also be a challenging factor in some small and medium organisations. However, the long-term impact can be scalable and widely accessible [46]. Intellectual properties of the content itself can also be restricted in some cases and limit the opportunity of sharing it, and this can go both ways [33]. Finally, the top management endorsement is vital to ensure that a knowledge-sharing and learning culture is in place [19,44].

4.3. RQ3. What are some of the emerging trends and technologies in eLearning?

Many significant trends emerged in eLearning in the last decade (Table 5). Some of them impact learners' outcomes and enhance their learning experience. These trends include Mobile Computer-Supported Collaborative Learning (mCSCL) [47], game-based learning - Gamification [48], flipped classroom [50], using Deep learning and artificial Inelegance in the eLearning field [46] and Open Educational Resources (OER) [36]. What the majority of these trends have in common can be summarized in their ability to provide social interaction, fun, and interactive and unlimited access. The instructor becomes a facilitator; learners are in control, and they co-create the new knowledge [47].

Table 5: The main trends and technologies eLearning found in the reviewed papers

Ref.	eLearning	Knowledge-Based Economy	eTraining	Moodle	Deep Learning	mCSCL / mLearning	Gamification / Serious Gaming	Flipped Classroom	OER / MOOC
[19]	X	X							
[33]	X								
[44]			X						
[45]	X			X					
[46]	X				X				
[47]						X			
[48]			X				X		
[51]	X							X	
[50]	X								X

5. Discussion

5.1. eLearning capabilities & OP

In [19], the study discussed the impact from an economic development perspective. As the economic evolution is witnessing a shift from an industrial-based economy to a knowledge-based economy, the whole country's performance, and not just the organization's, depends on the human capital being equipped with the necessary academic skills. Learning capabilities remained the key challenge in a country like Malaysia to fully transform its economy into a knowledge-based one. This study valued learning capability as a vital role for remaining competitive. Successful organizations are those that can capture intalactual assets by managing their knowledge. The paper also acknowledged the critical role of top management, as they need to understand the best way to combine and share the knowledge sources to improve the company's performance. Once learning capabilities are rooted and embraced as part of the organizational culture; it will lead to increasing the competency level of every single individual, driven by the role of its KM system. Only then can the organization reach its full potential and increase its competitiveness performance [19]. However, the author did not specify what methodology was used to reach his findings, and he did not support his findings with examples or case studies.

The study by [33] pointed out how eLearning capabilities could reduce training costs and have a long-term impact on reducing operational expenses, which would lead eventually to better financial performance. Some researchers think organizations that create and share open-learning resources should be exempt from taxes.

The results of [44] also confirmed the [33] finding in cost savings. The study highlighted the importance of eLearning and its impact on individual performance. One direct impact of endorsing eLearning capability can be a huge amount of saving in training. This saving includes travel expense and training time. Other advantages include flexibility in self-based training and the variety and availability of training content. The eLearning model can also guarantee unified training for all, which will keep the resource inside the organization. The business will not be interrupted by those who take leave for training. This will increase the workers' productivity and the number of skilled and trained human capital, which ultimately will allow the business to remain competitive [44]. In addition, long-term organizational success is linked to embracing a learning culture among employees. One significant finding is the role of the eLearning infrastructure on employee performance.

The results of [45] are in line with the above findings, as the authors also found that eLearning is the most effective method of knowledge transfer. The authors examined how different learning capabilities can impact executing a successful KM strategy and improve the chance of knowledge sharing among individuals, which ultimately will lead to improving an individual's productivity and OP.

Three knowledge transfer types were used (email, teleconference, and eLearning), and eLearning proved to have the most significant impact. It created a sharing culture and a common place to retrieve information, but the authors also pointed out that further investigation was needed to ensure that the reuse of this module would lead to performance improvement [45]. Although the study used Moodle, an open-source eLearning platform, it did not discuss the security issues associated with open systems and platforms.

The study also highlighted the importance of matching learning modules with the right organizational needs; this will result in improving OP. In addition, the learning capabilities involving the use of eLearning modules can constitute a useful tool for sharing knowledge. This system will allow "just in time" training that will enable employees to cope with the necessary changes to their overall performance.

Another way in which an organization can use eLearning to stimulate their performance involves sharing their knowledge in an open platform or on the company's website, where they can attempt to gain customers' trust and attract talent's confidence. It is also a way to enhance the organizational image and reputation. In addition, the distribution of free learning materials can lead to an individual doing something for free in return. A study [33] has also highlighted the increased willingness of individuals to engage in an activity associated with a company after benefitting from free services such as knowledge sharing.

The results of [46] support the proposal of [33]. Deep learning applications in eLearning can automate this process and boost the repurposing of current organizational learning resources to create more customized experiences and content using the power of the natural language process (NLP) and machine learning.

5.2. Challenges in eLearning

In [19], the authors pointed out that, as everyone could imagine, eLearning practices were not a comfortable ride. The biggest obstacle in this paper was not the technology or the KM itself. Surprisingly, it lay in the human factor of the process. It has been found that employees can resist sharing the necessary knowledge. Individuals in organizations may argue that sharing the knowledge they have will threaten their existence in the organization, leading to their replacement with younger, cheaper staff. In addition, the embracing of comfort zone culture in organizations can be a barrier to making use of the full potential of eLearning tools. However, this finding could have been enhanced if it is supported by more concrete evidence. Further studies are needed to support this claim.

In [33], the study referred to an unfortunate widespread belief that if something like eLearning is free and accessible by all, such as OER, it might mean it is worthless. However, these concerns are not in line with those of [52], who found OER improves students' grades and addresses attainment gap concerns. They also offer opportunities for part-time students and populations historically underserved by higher education.

Intellectual properties were also raised in this study, where content producers restricting the reuse, editing, combining, or distributing of training materials. Language can also be a barrier for those who do not speak English as a second language. The same also applies to cultural diversity; the contextual gap can be another challenge that will result in a barrier for understanding not only the words but the context of the concept expressed through them.

The results of [44] are consistent with that, as the findings pointed out the importance of the simplicity and the accessibility of the eLearning platform as it might be an obstacle of the user interface was not interactive or attractive enough [44].

In [53] the authors have discussed the role of the eLearning resource quality and how the message of the content can be lost in the process. The issue related to updating multiple organizations, scattered in different locations from one credible source. Banks industries, for example, are impacted by several changes based on the economic situation. This industry is regulated by government economic policies that keep constantly changing to respond to the economic situation. Delivering these new updates effectively and swiftly is essential to bank employees. Banks are usually developing eLearning capabilities to inform their employees with these continuous updates; however, lacking a suitable mechanism to understand the quality of the learning resources can affect the understanding of these updates, resulting in outdated products and services, and eventually effects the bank's performance [53]. Unfortunately, high-quality content is usually associated with high cost. The results of [46] reinforce that by flagging out the cost involved in developing learning content. Although eLearning facilitates learning anytime and anywhere, the initial cost of developing eLearning resources can be a barrier to further deployment on an organizational level [46]. However, [46] also suggests tackling the cost linked with content development by using deep learning applications in reusing and purposing existing content, and save cost for the long-run.

5.3. eLearning emerging trends

In [47], the paper has discussed the mobile devices as one of the learning tools enhancing corporative learning. They describe the mobile learning operationally by a cooperative social process, supported by handsets, where the participant uses their handsets to interact internally and externally, to share and generate new knowledge. They used the terminology "mobile computer-supported collaborative learning" (mCSCL) to describe these activities. The paper also found six emerging perspectives on what learners are experiencing in mobile learning nowadays. They summarised their finding in the following points: 1) Social interaction is necessary, 2) Unlimited learning experience, 3) Learning becomes fun and interactive, 4) Instructor is becoming facilitator, 5) Learners control their learning between each other, 6) Learners value the co-creation of new knowledge [47].

A study by [48] highlighted another emerging field in adapting eLearning in an organization using game-based learning. These learning tools utilize the psychological readiness of individuals to engage in games. Game-based learning uses the same motivational and addiction mechanism used in video games and applies it to real-world activities to make them more enjoyable and attractive. The efforts focused on employing gamification techniques in the workplace to motivate, training and recruiting. Game-based training increases engagement, motivation, performance, and retention.

The study uses some empirical evidence as a successful application of game-based learning in the workplace environment.

Including L'Oreal, IBM, Cisco, Deloitte, and McDonald's. Whereby these companies have developed and implemented gamification and serious games as part of their overall training strategy. The impact has been measured by reducing lost time, an increase in engagement, and an increase in revenue up to USD 30 million [48].

In [50], the results suggested a flipped-classroom approach to improve learning outcomes. Flipped classroom or flipped workshop is considered an effective learning way by many researchers. The flipped classroom concept focuses on post-course activity, forcing learning to prepare and preview the material outside the class hours. For example, online learning tools are usually utilized, and learners have to attend online learning materials provided by the trainer before joining the actual class. The early finding indicates an improvement in learner's performance.

Authors of [46] have highlighted deep learning using artificial intelligence as one of the emerging trends in many eLearning fields. The value of deep learning comes in its ability to offer learners intuitive algorithms, automated delivery of content, the ability to swiftly reuse the current resource, and decrease the cost of content development. Some deep learning applications in eLearning includes Personalized learning path, Chatbots Performance indicator and Virtual teaching assistant.

The study of [33] discussed the role of OER in eLearning applications. The advantages of OER have gained increased attention worldwide; this could be for OER's potential in overcoming educational, demographic, economic, and geographic limitations. OER can come with various models, for example, the 4A model characterizes OER in the following As Accessible, appropriate, accredited, and affordable. In contrast, the 4R model characterized it in a 4R model, these Rs are: Reuse (open license of applying all or part for an individual goal), Revise (Editing, translating and modifying the content, Remix (Combining two materials to create a new resource and Redistribute (sharing with others).

The MOOC is one of the well-known concepts that has emerged from OERs. MIT's open courseware, for example, is the largest provider of such courseware. Up to 2015, MIT has successfully archived 2,250 training courses, and 450 training courses are being added annually. Many educational institutes have followed MIT's practices policy in publishing free open courses on MOOC platforms, such as Coursera, Edx, and Udacity platforms. Some corporations have even started to follow that practice, including IBM, Microsoft, and Google [33].

6. Conclusions

This paper has explained the importance of eLearning as a knowledge transfer tool on OP. It has also discussed the challenges and obstacles of applying eLearning tools and has highlighted the recent eLearning trends from 2016 to 2020. This study has further shown how individual LLL is critical in creating a knowledge-based economy and how eLearning capabilities provide an ideal solution for that mission. The research has shown that eLearning can impact OP in many ways. Also shown was the importance of matching learning modules with the right organizational needs in order to achieve the desired performance. One of the more significant findings is that sharing knowledge externally on an open eLearning platform can lead to gaining customers, attracting talent, and increasing a company's reputation and value. However, many of the findings discussed need further investigation. There is little known on how eLearning capabilities have impacted organizations during and after COVID-19 in different regions. Further study suggested studying the impact of eLearning as an LLL practice. Moreover, researchers must look at how students, young people, and senior employees engage in the eLearning platform, determine what motivates them, and decide how to validate their learning outcomes.

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Comparison between Collaborative Filtering and Neural Collaborative Filtering in Music Recommendation System

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ABSTRACT

Music is one of the most popular entertainments, and the music industry continues to increase over time. There are many types of genres in music, and everyone has their own choice of the type of music they want to listen to. The recommendation system is an important function in the application, especially when there are a large number of choices for a particular item. With a good recommendation system, users will be able to get help from the suggestions given and can improve the user experience of the application. By using collaborative filtering (CF) methods to recommend products related to personal preference history, this feature can be better provided. However, the CF method still lacks in integrating complex user data. Hybrid technology may be a solution to perfect the CF method. The combination of neural network and CF also called NCF is better than using CF alone. The focus of this research is a CF method combined with neural networks or neural collaborative filtering. In this study, we use 20,000 users, 6,000 songs, and 470,000 records of ratings then predict the score using CF and NCF approach. We aim to compare the recommendation systems using CF and NCF. The study shows that NCF is better in gathering certain playlists according to one's preferences, but it takes more time to build compared to user-based collaborative filtering.

1. Introduction

Music is one of the most popular entertainments. There are 1.15 trillion users who stream video and audio-based music on digital platforms in 2019 and increased by 29.3% from the previous year. The increasing number of users are based on the fact that music could control people's emotions, moods, or physiological arousal [1]. Besides users, music content also increases a lot every year. Large numbers of music content are making it hard for people to search relevant music, especially when it is unorganized. Therefore, there is a need to organize all music content, but it is very time consuming to do manually. In order to simplify this process, some music applications like Spotify and Youtube Music implement recommendation mechanisms or systems [2]. This recommendation system can suggest a list of relevant music from the library and becoming popular nowadays and crucial to prevent their customer to move on to another service [3].

Recommendation systems use two main approaches, content based and collaborative filtering (CF). Content based approach focuses on item metadata or attributes. For example, a music described by genre, singer, producer, etc. Otherwise, CF approaches focus on user preferences and are called as personalized recommendation systems. This approach analyzes the relationship between user and item. Similar users tend to be interested in similar items. User similarity can be measured by their history or review. Afterwards, user-item relation is used to predict what item might be liked by other users similar to him. Suggested items may vary for each user, due to different interests. Thus, CF approach has become popular and widely used in recommending items [4].

In CF, matrix factorization (MF) becomes one of the most popular techniques besides neighbour-based using similarity metric. Unfortunately, MF performance impeded due to inadequately capturing an advanced structure of user interaction data. Thus, it is required to develop another technique by using MF approach to obtain better results [5]. Recommendation system nowadays widely implements hybrid techniques in order to overcome limitations of the CF approach [2, 3]. An approach by combining both CF and neural networks is one of the hybrid

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techniques used widely for learning the interaction function from data [5].

Collaborative filtering approach combined with neural network or called neural collaborative filtering (NCF) enthrall this study. The aim of this study is to compare NCF with user-based CF. In this paper, we also implement collaborative filtering and neural collaborative filtering in a digital online music application. After a user logged in, the system will provide recommendations with the two methods along with the predicted rating.

This paper consists of 5 sections starting from the review from previous work in section 2, followed by methodology in section 3. In section 4, we discuss the experiment results of neural collaborative filtering compared with user-based collaborative filtering. Finally, we concluded our study with suggestions for future research in section 5.

2. Related Work

Recommendation system is a system that is used to predict an object as a suggestion to a related user. Suggested item expected to be liked or relevant to user's interest. It consists of two different strategies, which are the content-based approach and CF. Content-based approach, did its job by distinguishing the product's nature. CF on the other hand relies only on past user behavior. It then complicates the use in the beginning since it is unable to address products new to the system, and so called the cold start problem [6].

Collaborative filtering uses two types of input, those are explicit and implicit feedback. Those feedbacks are used as user-item interaction. For explicit feedback, data acquired explicitly from user input in response to portray if the user is interested in an item. However, not every user likes to give their thoughts about an item, so explicit data is not always available. This underlines the reason why we need to observe user behavior to acquire the implicit feedback. Examples of implicit feedback are mouse click, the number of times a video or music played, etc. An implicit feedback has an inherently noisy nature, it requires appropriate measures for evaluation, and the numerical value indicates confidence [6].

The CF approach is widely used in e-commerce, movie/video/music platform, food application, and social media - Facebook, Instagram, Twitter. There are two types in CF approach, those are: user-based and item-based. User and item-based CF are alike, where user-based search the items that a user interacted with. While item-based search which users interacted with this item. Collaborative filtering approaches are used widely nowadays. Research by [5,7–11] implemented CF and showed that CF resulted in high accuracy and suitable for recommendation systems. This approach has for about 2 thousand users, and the accuracy is 80-90% [9]. While research by [12] gives 0.8 and 4.5 as the highest RMSE and MAE value, respectively.

The principal in creating a neighbour-based CF recommendation system is to identify user similarity from their preferred items, then select top most similar k users [5,10,11]. Neighbour-based CF provides good recommendations. Research by [12] shows that multiple processes to predict rating with k=1 and use the average of item's ratings gives better performance in terms of precision, recall, accuracy, MAE, MSE, etc. Research by [3,11] shows that a recommendation system with kNN-based CF does well in predicting rating of song given the attributes with a small error value. Another method for CF is using latent vectors to represent users and items, called matrix factorization (MF) [7]. In this process, the inner product of those latent vectors become the interaction between user and item, or ratings. Latent-vectors factors are learned in MF method by minimizing the loss or difference between actual and predicted ratings [13]. Deep learning like recurrent neural network (RNN) can represent better user interest from the latent-vectors factors [14].

Even though those techniques perform well, it also has its deficiency. Therefore, fusing one technique to the others could be more promising in providing better recommendation. Nowadays, combining/hybrid techniques are used widely in machine learning and also recommendation systems. By combining technique, each technique is expected to overcome others' limitations [2,3,15]. One of which is by combining with neural networks for learning the interaction function from data. It is supported by a paper that stated that neural collaborative filtering (NCF) or combination of MF with neural network shows that NCF with 4 layers results in greater HR@10 and NDCG@10 value [5]. Another hybrid approach proposed by [14] called multiple user interest representation (MUIR), combined CF and content based filtering aspects using deep learning which resulted in better precision, recall, NDCG values compared to content based filtering and other methods. Based on those hybrid techniques, it shows that combined techniques produce better results and complement one's weakness.

3. Methodology

In this section, we will explain our steps on building a song recommendation system using user-based collaborative filtering and neural collaborative filtering as shown in Figure 1.

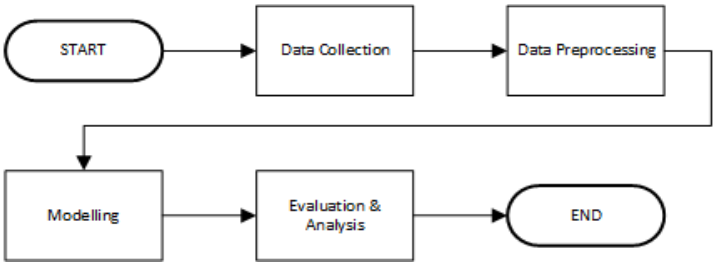

Figure 1: Steps of the Music Recommendation System Research

3.1. Data Collection

Data used in this study consist of users, music, and the total number of times the music was played. There are over 20,000 users, 6,105 music, and 470,759 records about the number of times music was played.

Figure 2 shows the ERD used in our digital online music application. The "playlistcount" (3rd) table contains the implicit feedback of the number of times each user heard a song. The "playlistrating" (4th) table shows the rating data of each user for a song that is heard. The 3rd table has a close relationship with 4th table where the rating is obtained from normalizing the number of times a user listens to a song. Calculation of normalization will be discussed in Chapter 3.2.

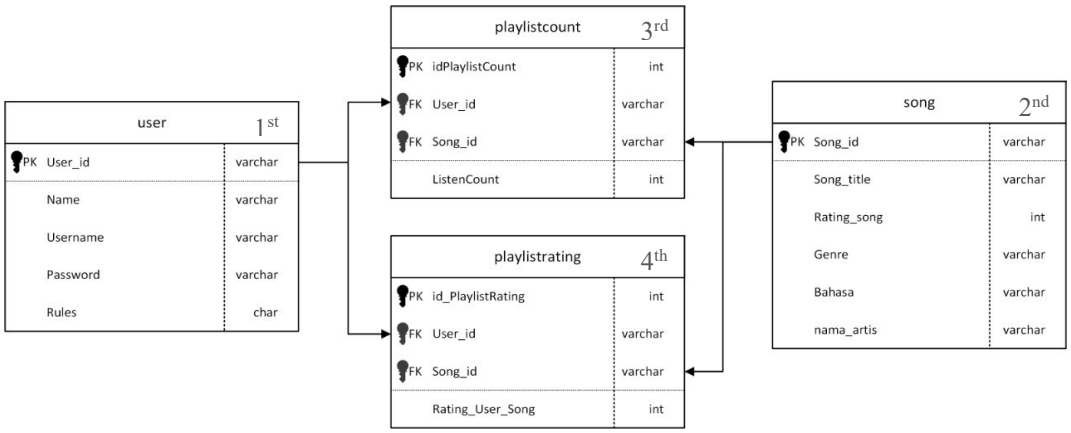

Figure 2: Entity Relationship Diagram of Music Data

3.2. Data Preprocessing

We need to normalize the number of times the music is played c_{ui} due to different habits each user is likely listening to. The normalize value then considered as rating r_{ui} – the rating from user u for item i as shown in Eq. (1):

$$r_{ui} = \frac{c_{ui}}{Max(c_u)} \times 100 \quad (1)$$

The denominator of Eq. (1) search maximum number of times user u listened to a music. The rating value is then stored in the database on the 4th table as shown in Figure 2 and used for suggesting music content to each user. It is ranging from 0-100.

3.3. Modelling

To predict personalized music rating, we use two techniques, that is: user-based collaborative filtering and neural collaborative filtering. For those techniques we use the same preprocessed data discussed before. All models were run on Google Colaboratory with its GPU runtime.

3.3.1. User-based Collaborative Filtering

For user-based collaborative filtering, we first choose a user u, then we find similar user candidates by seeing if they have listened to the same music. Due to lots of users in the database, we use sample candidates of n users. Next, compute correlation or similarity between user u and similar users' candidate. In calculating the similarity of two objects, we can use similarity metrics, such as cosine similarity, pearson correlation coefficient (PCC), and mean square distance (MSD). In this study, we use PCC formula [7–9,12] as shown in Eq. (2):

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (2)$$

In Eq. (2), x represents ratings from user 1, while y represents ratings from user 2. The output of pearson correlation (r) ranges from -1 to 1 representing how similar is user 1 and user 2. The value of r = -1 when there is a perfect negative correlation, r = 0 means there is no correlation at all, and r = 1 means there is a perfect correlation. Next, we sort similarity users in descending order as it represents the most similar preference with user u and choose the top 50 users. After that, we predict the rating.

There are several methods for predicting rating, such as weighted average (WA), mean centering (MC), and Z-Score (ZS) [12]. In this study, we use the weighted average method. Correlation value with the top 50 users then used as a weighting factor in order to calculate predicted rating by weighted average as shown in Eq. (3) [12]:

$$\dot{r}_{ui} = \frac{\sum_{j=1}^{n_{ui}} sim(i,j) * r_{ju}}{\sum_{j=1}^{n_{ui}} |sim(i,j)|} \quad (3)$$

where:

- sim(i,j) is the output of PCC of user i and j similarity
- r_{ju} is actual rating from user j of item u
- $\dot{r}_{ui}$ is predicted rating from user u of item i

In CF, we split data into two sections: training and testing. First, we take 5 given ratings by each user and use it as a testing data. Therefore, we have 376,617 as training data and 100,000 as testing data. While predicting test data, the model could output NaN values, so we do not consider when calculating errors.

3.3.2. Neural Collaborative Filtering

Neural collaborative filtering approaches combine general matrix factorization with neural network matrix factorization as shown in Figure 3. This model combines linearity of GMF and non-linearity of neural network in modelling user-item interaction. This model was built by using Keras. Extra preprocessing was implemented when building this model because our input data consist of strings. We then use labelencoder provided by the sklearn library to encode and decode user and music id. Encode is necessary to build the model while decode is used when predicting rating for the user.

For each input, that is: users and music, we create embedding or latent factor with a size of 64 for each item. Then, we multiply item and user embedding as a layer for general matrix factorization (GMF). For the neural network layer, it aims to learn user-item interaction representing predicted rating matrix. Concatenating the item vector with the user vector has been widely used in multimodal deep learning network. However, it does not consider user-item interaction [5]. So, we use a multi layer perceptron (MLP) to learn the interaction function. First, we concatenate item and user embedding and use four hidden layers

with 0.25 as a dropout rate. For each hidden layer we implement a linear activation function, ReLu R(x) as shown in Eq. (4). The value of R(x) ranges from 0 to infinite. Then, we concatenate GMF results with the matrix generated from the MLP layer as NeuCF layer. Last, the output of NCF is given by using ReLu activation function on NeuCF layer's output. The formula used in NCF model are shown in Eq. (5) - Eq. (7) [5].

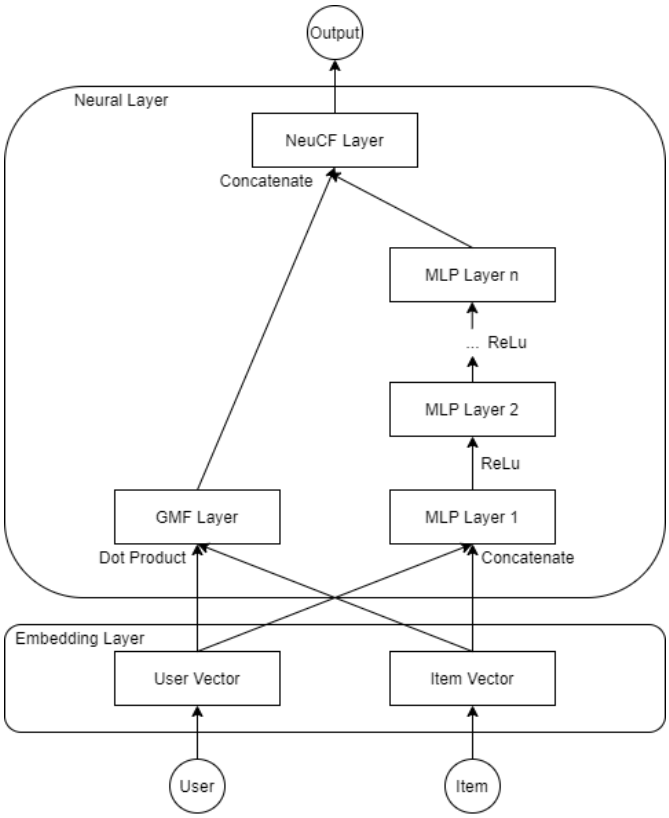

Figure 3: Structure of Neural Collaborative Filtering

$$R(x) = \max(0, x) \tag{4}$$

$$GMF = p_u \cdot q_i \tag{5}$$

$$\text{MLP} = \alpha_L\left(W_L^T\left(\alpha_{L-1}\left(\ldots\alpha_2\left(W_L^T\begin{bmatrix}p_u\\q_i\end{bmatrix}+b_2\right)..\right)\right)+b_L\right) \tag{6}$$

$$y_{ui} = R\left(h^T\begin{bmatrix}GMF\\MLP\end{bmatrix}\right) \tag{7}$$

For all formulas above, p_u and q_i denotes user and item embedding respectively. We define this task as a linear regression problem as we intend the output of NCF is the predicted rating value. Therefore, we use mean square error (MSE) as the loss function. Parameters used in this model are shown in Table 1.

Table 1: NCF Model Parameters

Variable	Value
Batch size	64
Epoch	10
Learning rate	0.001
Optimizer	ADAM

In the neural collaborative filtering approach, we split the data into training, validation, and testing data. The percentage of testing data is 20% of all data and 80% for training. The training data is then split into training and validation, with a percentage of the total data validation of 20% of the training data. Therefore, we have 301,285 as training data, 75,322 as validation data, and 94,152 as testing data.

3.4. Evaluation

Since the recommendation system output is predicted rating, we use regression evaluation metrics. We use mean absolute error (MAE), Mean Absolute Percentage Error (MAPE), mean square error (MSE), and root mean square error (RMSE) for the calculation. The evaluation and comparison of our music recommendation system presented as a value of actual and predicted music rating. The formula of each evaluation metrics is shown in Eq. (8) - Eq. (11):

$$\text{MAE} = \frac{\sum_{i=1}^{n}|y_i - x_i|}{n} \tag{8}$$

$$\text{MAPE} = \frac{\sum_{i=1}^{n}\frac{|y_i - x_i|}{y_i}}{n} \times 100\% \tag{9}$$

$$\text{MSE} = \frac{\sum_{i=1}^{n}(y_i - x_i)^2}{n} \tag{10}$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n}(y_i - x_i)^2}{n}} \tag{11}$$

Where x and y represent predicted and actual value respectively.

4. Experiments

Our experiments take two steps, which are searching the best architecture used for NCF and comparing it with user-based CF. Table 2 and Figure 4 below shows the performance of NCF given different architecture on validation data. We test the model using 32, 64, and 128 latent vector factors or dimensions with 3 and 4 hidden layers. We use 3 and 4 hidden layers based on experiments by [5] which shows that 4 hidden layers results in better NDCG@10 value and 3 hidden layers once give the best NDCG@10 value. For every number of latent vector dimension, it is true that 4 hidden layers model gives less error than with 3 hidden layers. It also showed that 64 latent factor dimensions gives better error performance with about 5 value difference between the lowest error of 32 and 64 latent factors.

Table 2: Neural Collaborative Filtering Performance with Different Architecture

Layers	Factor	Highest Error	Lowest Error	Average Time to Build
3	32	29.123	20.271	13 minutes
	64	26.097	16.480	29 minutes
	128	25.655	24.086	55 minutes
4	32	25.799	15.879	15 minutes
	64	25.201	15.697	30 minutes
	128	25.397	23.676	57 minutes

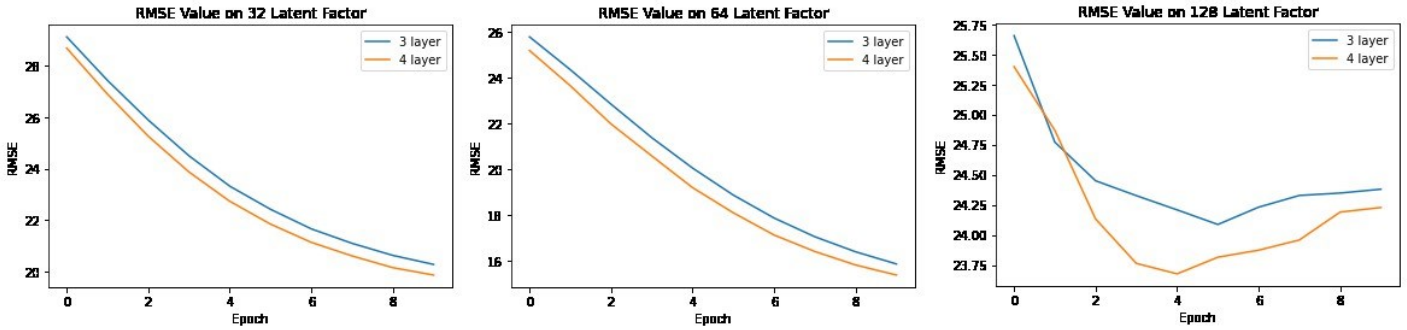

Figure 4: RMSE of Neural Collaborative Filtering on Testing Data

Evaluation metrics of CF and NCF shown in Table 3 below are calculated based on the 94,152-test data. Based on the result, it is shown that NCF is better than user-based CF, as it has lower error calculated with MAE, MAPE, MSE, and RMSE. Other than that, CF error has a big difference with NCF with about two times larger. These errors seem to be larger than other research mentioned before because we use a wider range of 0-100 for each rating. It is not surprising since there are some limitations in PCC. Some of the important limitations by PCC are that similar users could only be calculated if there is an overlap over the rated items and due to CF sparse data makes PCC results NaN measure [15].

Table 3: Collaborative Filtering and Neural Collaborative Filtering Performance

Method	MAE	MAPE	MSE	RMSE
CF	14.866	66.118	645.786	26.107
NCF	7.933	28.591	246.422	15.697

Table 4 below shows the predicted rating by using CF and NCF. We use 3 users given 7 sample music to see the difference between actual and predicted rating by both CF and NCF. The closest difference means that the framework predicts better results. NCF framework gets a 21/27 score and reflects that NCF provides more appropriate and optimal recommendations compared to CF.

Table 3: Sample of Recommendation Score

# User	# Song	Actual	CF Score	NCF Score	Winner
1	1	34	43.666	25.124	NCF
	2	13	28.5	10.368	NCF
	3	20	54.75	40.449	NCF
	4	17	13.3	18.745	CF
	5	17	19.66	22.226	CF
	6	3	27	25.456	NCF
	7	6	26.8	25.338	NCF
2	1	5	20.4	17.052	NCF
	2	50	58	51.9	NCF
	3	20	54.75	40.449	NCF
	4	5	13.5	13.961	CF
	5	5	17.666	6.296	NCF
	6	5	23.375	6.747	NCF
	7	11	85	34.424	NCF
3	1	33	30.2	26.475	CF
	2	33	23.25	29.868	NCF
	3	66	44	26.472	CF
	4	33	16.666	30.487	NCF
	5	33	37.5	39.8	CF
	6	33	13.666	40.82	NCF
	7	66	33.2	44.707	NCF

Table 3 and 4 represent NCF framework is better than CF alone as it gets less error in predicting rating. Unfortunately, NCF needs more time to build a model with approximately 25-30 minutes with our model using Google Colaboratory GPU runtime. However, it is worth implementing NCF as it predicts more accurately and faster than user-based CF when using pre-build NCF model. The NCF model needs 5.24 seconds while CF needs 12.16 seconds in recommending music. Therefore, the NCF model must be trained first and stored so that in its application, it is only necessary to load the model.

The experimental results were obtained by following the stages, methods, and architecture described in Chapter 3. The parameters described in Chapter 3 are the best parameters to get optimum results based on several experiments such as changing the number of latent factor dimensions and the number of hidden layers. Other than that, we also consider the time to build the model with the difference of the errors.

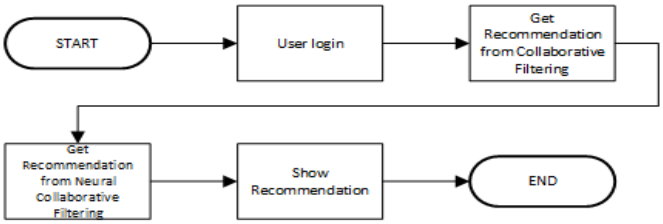

Figure 5: Application Workflow

The disadvantage of doing a load model is that it cannot cope with significantly changing conditions. The model is trained with existing data, if there is a change in behaviors, the model cannot handle it. To overcome this, the model must be trained regularly so that changes in user habits can be learned and the system provides appropriate recommendations. In this application, model training is carried out periodically using recurring jobs. With the recurring jobs that carry out training with the latest data, it is hoped that it can overcome significant changes in user behaviours.

An example of a user interface of our application can be seen in Figure 6. After the user logs in, 2 recommendation options will be given, using CF and NCF, this process on our application shown in Figure 5. On that page, the predicted rating for each recommended music is also displayed. There is no identical music on the top 9 recommendations based on CF and NCF. In NCF the predicted ratings are more varied rather than CF results.

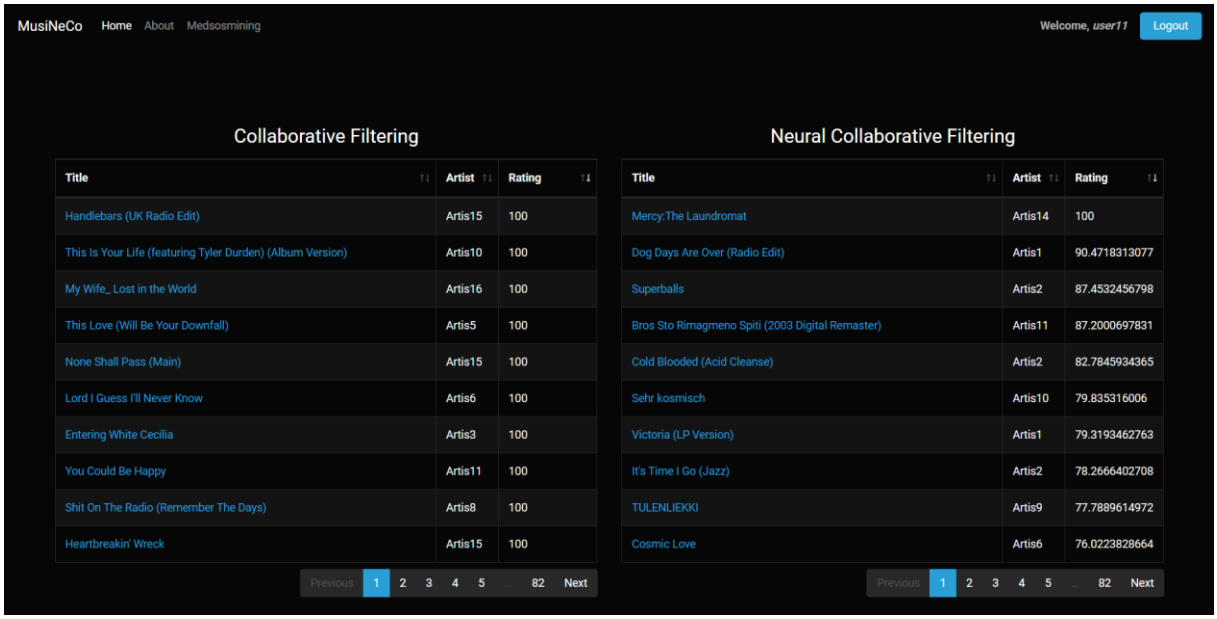

Figure 6: Music Recommendation Application

5. Conclusion

Our study focuses on NCF then compared with CF approach on music dataset. From the results discussed in Chapter 4, it can be concluded that NCF produces better recommendations than CF in terms of errors, predicting ratings, and time used to predict. It is unsurprising that NCF gives better performance since it learns the user and music embeddings that more similar users in the context of preferred music are closer to each other in the embedding space rather than single correlation calculation performed on CF. Moreover, recommendation model from NCF could be used repeatedly on giving recommendation without recalculating similarity between users when needed. However, building NCF model needs more powerful computation power due to massive matrix manipulation needed.

In addition to making comparisons between CF and NCF, we also make comparisons with several model parameters to the NCF model in order to obtain an optimal model. Model with more hidden layer may converge in a higher level of abstraction. It is proved in this study that four hidden layers model gives smaller error paired with small time difference when building the model compared with three hidden layers model. The result of this study can be implied to increase people's engagement with digital online music applications as it provides sufficient recommendations according to the user preference.

Although neural collaborative filtering has better results than collaborative filtering, this method has a weakness in terms of preparation time because it has to go through the build and training model stages. This stage takes a long time, so the alternative is to save the trained model and load the model to get recommendations. To solve the process time problem, the implementation of the application does not do real-time training instead, it loads a trained model. Further research on recommendation systems could contribute in proposing a new approach or combining several approaches to improve system performance, either in terms of times, effectiveness, errors, accuracy, or other performance metrics.

Conflict of Interest

The authors declare no conflict of interest.

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