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Interactive Learning Experience-Driven Smart Communications Networks for Cognitive Load Management in Grammar Learning Context

NADIA REFAT[1], MD. ARAFATUR RAHMAN[2], (Senior Member, IEEE), A. TAUFIQ ASYHARI[3], (Member, IEEE), IBNU FEBRY KURNIAWAN[4], MD. ZAKIRUL ALAM BHUIYAN[5], (Senior Member, IEEE), AND HAFIZOAH KASSIM[1]

[1]Center for Modern Language and Human Sciences, University Malaysia Pahang, Gambang 26300, Malaysia
[2]Faculty of Computer Systems and Software Engineering, IBM Centre of Excellence and Centre for Earth Resources Research and Management, University Malaysia Pahang, Gambang 26300, Malaysia
[3]School of Computing, Electronics and Mathematics, Coventry University, Coventry CV1 5FB, U.K.
[4]Department of Informatics, Universitas Negeri Surabaya, Surabaya 60231, Indonesia
[5]Department of Computer and Information Sciences, Fordham University, New York, NY 10458, USA

Corresponding authors: Md. Arafatur Rahman (arafatur@ump.edu.my) and Md. Zakirul Alam Bhuiyan (mbhuiyan3@fordham.edu)

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ABSTRACT The widespread adoption of technology-enhanced learning in various knowledge disciplines has pushed forward the development of information technology-assisted media for language learning and teaching. However, most of the existing electronic-learning (e-learning) solutions have underexplored and under-addressed given specific characteristics of grammar learning, which is one of the most demanding areas of language education. The lack of pedagogically informed instructional design to enhance learning performance on the current system can result in low motivation and engagement due to an imbalance and excessive increase of the cognitive load. This paper attempts to address these deficiencies posed by the existing systems by proposing smart communication networks that are driven by the student learning experience to manage cognitive load in the context of grammar learning. The e-grammar learning networks serve as a collaborative learning platform that combines a pedagogically informed instructional model named attention, relevance, confidence, and satisfaction (ARCS) and cyber interaction among teaching/learning agents. From the technological perspective, our numerical simulations demonstrate the desirable performance indicators of the proposed networks to facilitate information exchange and learning. From the education perspective, our empirical studies show that the overall smart network-enabled e-grammar learning system has desirable characteristics to motivate learners ($m = 3.78$) and manage their overall cognitive load ($m = 1.73$), which suggest the promising capability of the proposed system.

INDEX TERMS ARCS model, cognitive load, cognitive theory of multimedia learning (CTML), cyber interaction, e-grammar learning, e-learning, interactive, learning experience, motivation model, smart communications, smart networks.

I. INTRODUCTION

Grammar is an indispensable part of a language that elaborates the knowledge of proper and meaningful sentence construction. It is not only crucial for building sentences but also helps set up a linguistic background of any language. Grammar is commonly referred to as a set of rules that govern morphology, syntax along with sounds (phonology) and word meaning (semantics) of a language. Maintaining appropriate grammar knowledge is pre-requisite for effective uses of all language skills, namely speaking, listening, writing and reading) [1]. However, designing learning activities for grammar teaching is challenging since it requires a sustained level of motivation and skilled approaches. Consequently, teaching grammar through different media has been explored and exploited in the literature of language teaching

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and learning. Different teaching approaches with the incorporation of technologies (e.g., ubiquitous technology, device-to-device communications, smart phone, etc.) have topped the learning paradigm for years [2].

A growing way to learn grammar is through e-learning in which electronic devices such as computer or mobile phone are utilized within the learning activities. The so called e-grammar learning is predominantly self-directed where students are given more opportunities to design their tailored learning experience, which can be motivating and influential on learning effectiveness [3]. E-grammar learning can potentially enhance learning experience by allowing students to utilize technology-based learning tools that can improve self-confidence and self-control. In the current progress and development of e-learning, there are a few education tools for grammar learning that are available online [4]. However, the development of the vast majority of those tools has not been based on a strong foundation with rigorous pedagogical theory and consideration in many ways as follows. Firstly, the instructional design of the tools does not follow a research-informed motivational model, which is essential to instill interest and satisfaction of the learners (i.e., variation in different modes of presentations and feedback systems). Secondly, the instructional design adopts limited and often isolated multimedia properties (i.e., static images and graphics), which should have been comprehensively expanded (e.g., using audio, video, animation) to cater today's diversity in learning styles. Thirdly, empirical evidences on e-grammar learning tools that focused on the instructional design process are insufficient. Consequently, developing e-grammar learning applications, which can be utilized across different smart devices, are important to enhance students learning experience [5]. Ultimately, it is further highlighted that an appropriate design of instructional materials based on relevant motivational models is crucial for e-grammar learning in order to improve students motivation and manage their cognitive load [6]–[8].

One of the widely-referred motivation-based instructional models is given to Keller's ARCS model [9] that focuses on four major components of motivation, namely ARCS: Attention, Relevance, Confidence and Satisfaction, in order to create a successful instructional design. This model offers an effective way to promote motivation in learning and guides incorporation of such strategies into instructional design [10]. Furthermore, the model has been validated through multiple studies [11], [12] and acts as a tool with cognitive factors for analyzing motivational categories. Finally, the output of such model is commonly given by effective learning contents.

On a parallel remark, e-learning considers multimedia instructions with utilization of audio, video, graphics or animation, which can have positive effects on the human cognitive system and effectively manage the cognitive load. The affected learning information determines learner's working memory including intrinsic, extraneous and germane cognitive loads, which are sourced from mental loads and mental effort due to instructional design. Multimedia-based instruction reduces extraneous cognitive load if the sequencing of learning contents can provide balance of the intrinsic cognitive load and enhance the germane cognitive load. Moreover, multimedia-based instructional design has not been used for e-grammar learning, where the ARCS model and Mayer's Cognitive Theory of Multimedia Learning (CTML) [13]–[15] are exploited together. The limitation of the ARCS model is that it is unable to provide understanding on the mechanism to combine information processing elements with the learning elements and on their interaction with motivation [16]. Remark that non-linear features such as hotlinks and nodes as well as learners-driven random access to information are inherently present in self-directed multimedia learning platforms. In this case, the learnes would have the full capability to manage their learning process and achievements. Hence, CTML is included to address this limitation so that the instructional learning materials are affectively design for meaningful learning.

In order to design an effective e-learning system, automation and flexibility are desirable features that can unlock the unrealized potential of the system and thereby improve the learning experience and outcome. In this work, we consider smart communication networks that inherently embed such features and aim to jointly exploit the ARCS and CTML models for multimedia-base instructional design for e-grammar learning. Smart communication networks in the form of Internet of Things and Cyber Physical System have successfully been applied in a wide-range of domains, which incorporate information processing capabilities, such as wireless communications, robotics, artificial intelligence, sensor networking, learning method and navigation [17]–[20]. Motivated by this great success, this work attempts to incorporate smart communication networking approach on an e-grammar learning system. More specifically, the smart networks enable automation of the system where the devices are connected with each other through a network in order to achieve a common goal. Within a given learning system, it is really necessary to establish interactive communications among the students and teachers through a common platform, which will ease the learning process and improve the outcome of the learning. For this purpose, our smart networks will play a key role in establishing reliable interactive communications by exploiting network components such as smart phones, access points (APs), cloud service and server. Students and teachers are the end-users who will be connected with this network via mobile devices. Therefore, this study jointly integrates the ARCS and CTML to provide understanding on the establishment of learning motivation multimedia-assisted learning environments that are introduced through an interactive learning experience-driven smart network-enabled e-grammar learning tools.

Unlike the previous works, this study intends to understand the impact of cyber approach on a technology-based learning system in which internet-connected devices and objects are one of the emerging topics. Our findings are anticipated to support the implementation of educational technology in order to enhance language learning with a greater flexibility and potential. Moreover, the present work also attempts to investigate the outcome of a motivation-based instructional model, namely ARCS. Although such a motivational instructional model has been implemented in many other works to design instructions in different educational disciplines, to the best of our understanding, there exists no study that specifically targets the instructional design process for e-grammar learning and its impact on the learners. Finally, this work also aims to observe the outcome of this instructional design on the cognitive load of the learners on the ground that it appears to be directly related to the learners' motivational characteristics.

II. THEORETICAL BACKGROUND

A. RECENT WORKS IN E-LEARNING (MOTIVATION AND COGNITIVE LOAD ISSUES)

There have been expanded researches on computer-aided learning system where the researchers focused on the effectiveness of such technologies for language learning. Unlike the present proposed system, few studies only focused on vocabulary system [21]–[24]. In those research works, authors focused on the integration of ubiquitous technologies to introduce with new words in a given situations. Nonetheless, studies [23], [25]–[27] did not utilize IoT in their learning system.

Additionally, the lack of research on theoretical models for designing the instruction-based on motivational issue has motivated this study. ARCS is a model originally developed to examine motivational issues and subsequently recommend strategies to the design of learning instructions. Embedding the elements of Attention, Relevance, Confidence and Satisfaction, the model has been used in a wide range of instructional design contexts in order to bridge between motivation and intended learning outcome in classroom environment setting. The use of e-learning tools in the context stimulated students' consciousness about language learning strategies and motivation in a more communicative direction [21]. Apart from environment setting, this model is implemented to design instructions as to increase the motivation and performance in different language skills, such as listening skill [28]; writing skill or learning English and cultural values [29]. However, the model is not evident in grammar learning material designing with empirical evidences.

The other issue related to this proposed work design is cognitive load aspect which plays an important role in instructional design. Apart from increasing motivation, this model also exploits cognitive aspect for fostering the learning process. A learner's performance depends on the cognitive abilities that are influenced by the attention, relevance, confidence and satisfaction [30]. Moreover, motivation-based instructional design can enhance learners cognitive ability by managing cognitive effort [31]. An effective motivational instruction design develops a possible relationship between cognitive information processing and learning motivation. Furthermore, researchers also view that integrating multimedia based technology and motivational model for instructional design have relationship between memory capacity and resource management, and their effect on learning motivation [32]. Therefore, the systematic process motivational means and cognitive processing, instructional design can be effective for proposed grammar learning system.

E-learning infrastructure technologies have gained attention from scientists. A number of studies were conducted to improve content delivery performance from collaborative systems. Authors of [33] proposed a collaborative media streaming platform, Comodin, to deliver content diversification service specializing in e-entertainment and e-learning. An IP-based Content Distribution Network (CDN) was exploited in a way that clients can retrieve on-demand media from different proxies. There are two distinct planes handling content delivery and group-based streaming control. Other findings to enhance infrastructure performance with the help of social knowledge were provided in [34], [35]. In [35], the author formulated an algorithm to form group of agents in CoT environments by utilizing peers' trust and reputation. Trust metric is derived from agents' feedbacks, while reputation can be reflected by evaluation on agents' capability to accomplish task. Finally, a voting takes place to decide whether an agent belong to certain group. A slightly different approach was used in [34] where author mainly focused on Multi-Agent System (MAS). The study was able to create a mapping between two models to facilitate the development of autonomous system.

B. IMPORTANCE OF IMPLEMENTATION OF MOTIVATION COGNITIVE ASPECTS

Figure 1 demonstrates the ARCS model based instructional design using multimedia with cognitive development.

In Figure 1, the relationship of motivation (i.e., four criteria of ARCS model) and cognitive load is illustrated. Attention is assumed to be a pre-requisite for learning, which has to be acquired, guided and maintained through the appropriate stimuli by the learners. It has been well observed that whenever a strong level of excitability transverses to the brain region for stimulus detection, it is highly likely that a given stimulus catches the attention of the person, and vice-versa. Note that curiosity at a deeper level can practically be stimulated by constructing a problematic context that is resolvable solely by activities to seek the knowledge. Variability is also an important consideration for sustaining the attention over time, which aims to mitigate learners from adapting and moving out.

The relevance component highlights the significance of understanding the context of why it is necessary to spend effort to accomplish a task. Generally, the observation is that more motivation can be instilled to the learners if they develop a perception that the skill or knowledge to gain will be crucial for achieving the current/future goals. More specifically, people have tendency of developing a significant interest in contents and information that are linked to their prior

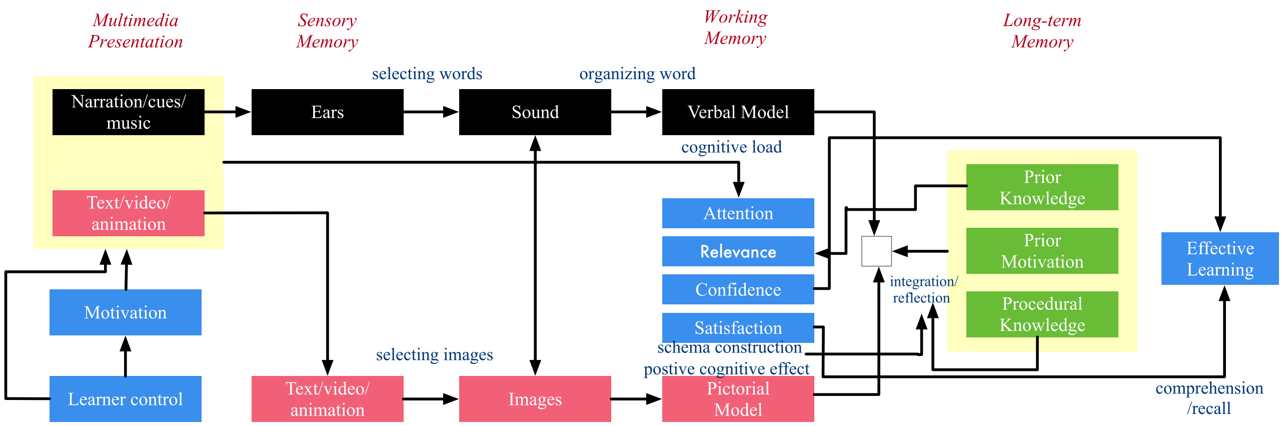

FIGURE 1. ARCS, multimedia, and cognitive architecture.

experience and existing interests. Therefore, teaching material that aligns with this observation can help achieve learning objectives. The confidence element underlines the pivotal role of acquiring confidence by the learners in achieving success in learning. Keller argued that informing the students to understand the learning expectation is a way to promote confidence. Learning confidence can often be related to facts or evidence presented in the learning materials or activities. When the evidence is well defined, rapid and accurate decision prevails, and vice-versa. Being presented with a lack of evidence could mean that a longer time is necessary for the brain to learn with possibly less accurate outcome, which may contribute to a lower confidence level of the learners. Finally, the satisfaction component highlights the importance of satisfaction feeling over a given learning process such that motivation for further process can be sustained. Internal and external methods shall be leveraged and integrated, not only to maintain the perception of control by the learners, but also to appreciate their working records and achievements.

In summary, most of these studies were conducted to examine learning benefits of the utilization of e-learning technologies. However, these studies did not look at nor apply motivation-based theoretical framework in the design nor use of the e-grammar learning tool. It is therefore assumed that ARCS model has been effective in different areas of learning, but in grammar, there is a need to explore more motivation-based learning approach. It is still an unexplored and interesting area to design such a mobile-assisted grammar learning tool based on ARCS model and measuring the impact of it on the learners. With ARCS model, designing effective instructional material for mobile users will be helpful for the learners to enhance their performance and motivate them to learn English grammar.

III. SYSTEM DEVELOPMENT OF THE INSTRUCTIONAL DESIGN

For instructional designing of the e-grammar learning tool, we consider two theories i.e., motivational theory and cognitive load theory. It is important to focus on the four basic components of motivational deign that are illustrated in ARCS model. The motivational component also affects the cognitive processing of information which is responsible for cognitive load. Instructional difficulty is responsible to cause intrinsic cognitive load where instructional presentation may reduce the working memory space and cause less extraneous cognitive load if the maintain of cognitive theory of multimedia learning are maintained in instructional designing. While the extraneous load is low it helps to organize and integrate the information from prior knowledge and acts role in schema construction. This new knowledge building is germane load which is positive for effective learning. The systematic instructional designing of the tool is graphically presented in the following.

Figure 2, demonstrates the correlation of e-grammar learning to motivation and cognitive load outcome that signifies two aspects of instructional design of the current work. Considering ARCS for designing learning content can improve motivation, cognitive load can be further managed as well due to its similarity to related models.

A. ARCS MOTIVATION MODEL

The research material of this study is a mobile-assisted grammar learning tool, which is a web-based learning application to help students learn English grammar. At present, although there are a few mobile-assisted learning tools on grammar learning, there are limited studies which discuss the development of these tools based on motivational aspects. The tools, aligns with John Keller model principle, is mainly designed to motivate, improve attention, find relevancy and confidence as well as usage satisfaction.

Initially, students may access various contents from the home page. As they navigate learning materials further, different exercise modules, of which items are based on Bloom taxonomy, are provided to assess their outcome level. According to the theory of motivation, any learning material must gain the attention of the students. Therefore, conversation and images were included as parts of the notes and task stimuli to generate learning interest. The tool also includes a variety of

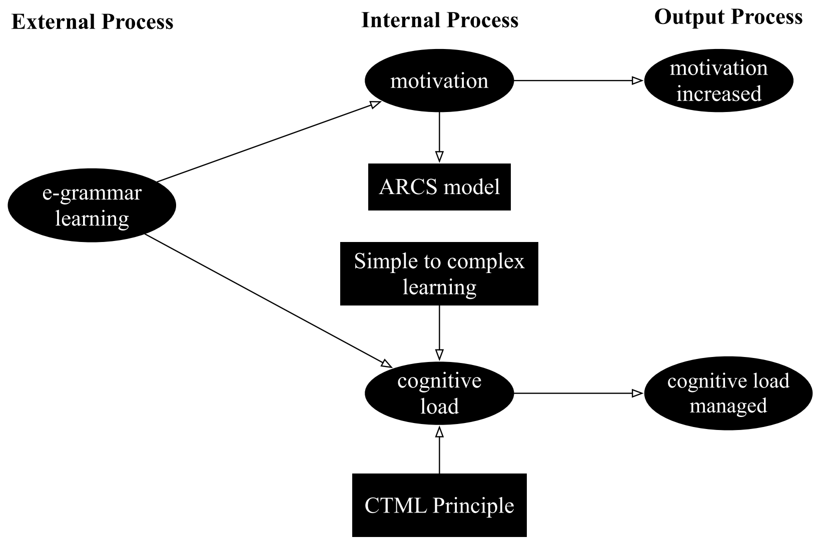

FIGURE 2. Correlation of e-grammar learning with cognitive load and motivation.

stimuli for input and notes to continue maintaining student interest.

To establish relevance of instructions, common examples and real life instances were included. The tutorials with examples are part of the learning module. Exercise module consisted of different types of question such as, fill-in-the-blanks, multiple choice question (MCQ), table matching, quiz, sentence building. The benefit of the exercises was to develop their confidence by providing the scores. It also provided the right answers if the students made mistakes in filling up the answers in exercises. This encouraged the students to learn more and judge their enhancement of performance.

This part is important to build student confidence during the learning process. Feedback is a very important part of learning as it motivates the learner to go ahead [36].

The final criterion in the model is satisfaction building. To manage student satisfaction, a self-evaluation part is included in the tool, where students were asked to answer few questions on English grammar. This part of evaluation is the outcome of their performance.

B. COGNITIVE-BASED INSTRUCTION DESIGN

Instructional design might cause cognitive load whereas a proper cognitive-based instructional design may not affect the working memory and increase learning. Therefore, to design multimedia-based instruction we consider three active aspects of information processing and followed the CTML principles. In the Figure 3, we demonstrate how the different kinds of cognitive loads are occurred due to instructional design and the proposed resolution.

There are five cognitive procedures in multimedia-based learning such as word selection, image selection, word organization, image organization and Integration, which have been specified by Mayer in 2001 [14]. Moreover, the cognitive requirements have been classified by him in to three categories such as, representational holding, incidental- and essential-processing [14]. Among them, incidental-processing plays key role for instructional task design. When this process is hampered it causes extraneous cognitive load. To reduce this load, in this e-grammar learning tool, followed coherence principle in text or images. Signaling principle is also applied in the instructional design of the tool to highlight the important information of the text or used audio as bringing the attention of the students that also initiates the essential processing with less obstacles. The spatial contiguity (i.e., corresponding words and pictures) should present together in the same page. The design of the e-grammar learning tool considers this principle along with redundancy principle to present the learning content without having extraneous cognitive load due to confusing presentation of learning content. Essential processing is cognitive process to comprehend any learning system, where the cognitive capacity will be utilized for integrating, organizing and selecting both images and words. The resolution of this cognitive load to maintain modality (People understand multimedia explanation better with narration than on screen text), segmenting and per training effect which are thoroughly used in the grammar learning tool. Lastly, representational holding considers the cognitive processes intended to recall a mental image over time on working memory in order to improve learning. Therefore, it is essential to reduce cognitive load, processing and holding time, which are tailed to design the grammar tool.

IV. THE OVERVIEW OF INTERACTIVE LEARNING EXPERIENCE-DRIVEN SMART COMMUNICATIONS NETWORK

Initially, students are required to download mobile-based application which is accessible on internet, and to complete registration process. Following this, they will go through several learning processes and some useful exercises that already designed in the application. Conclusively, they will give tests to evaluate their grammatical skills that have just learned from the application. To make this learning system

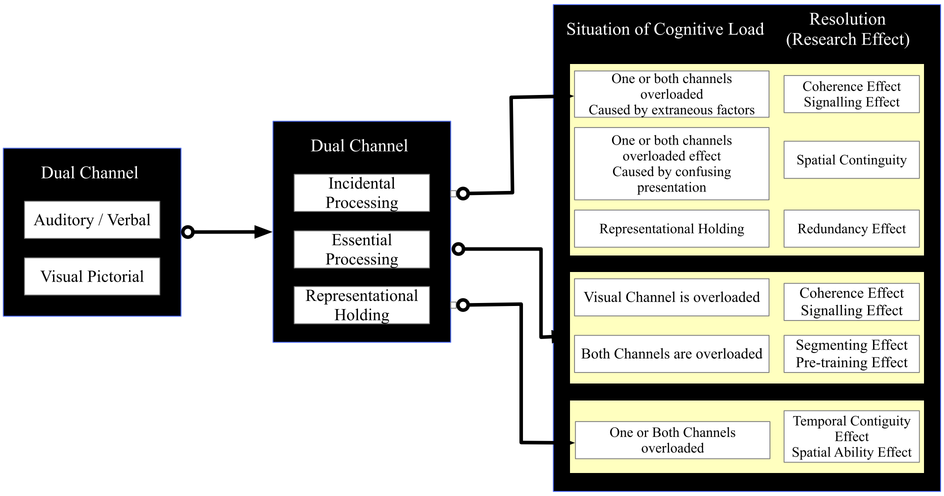

FIGURE 3. Cognitive-load and instructional design.

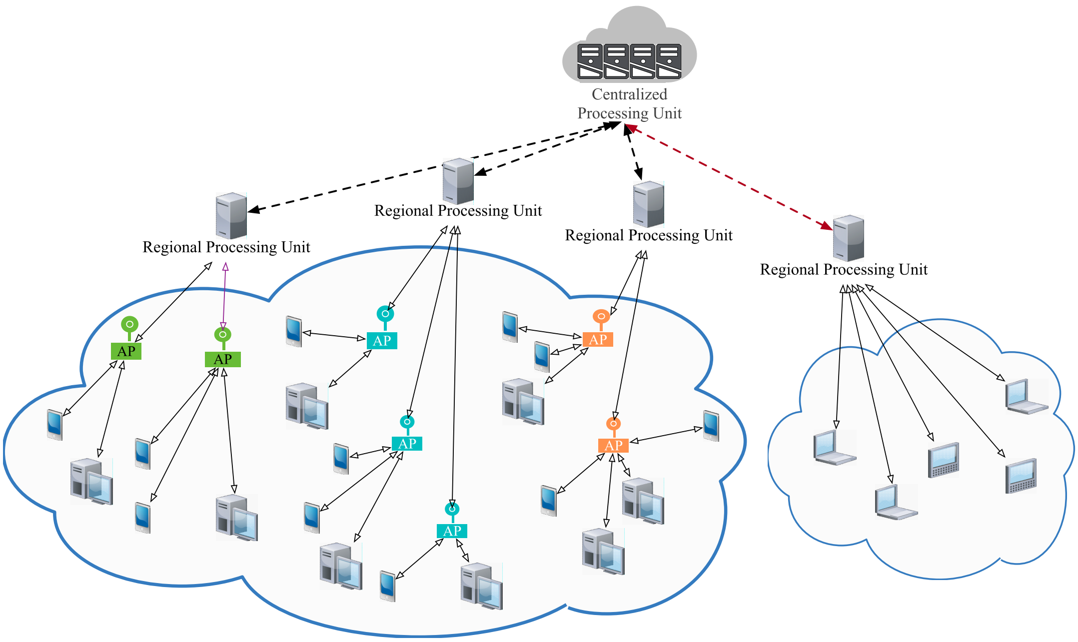

FIGURE 4. The architecture of the proposed interactive learning experience-driven smart communication system.

more efficient for the students, we have integrated wearable devices with internet connectivity into our tool in order to review learning progress and to communicate with peers at anytime and anywhere. However, the major issue in this case is that how the communication will take place in the system. We describe an overview of the e-grammar learning system as follows.

A. NETWORK ARCHITECTURE

Figure 4 illustrates the architecture of proposed e-grammar learning system. Two domains, students and teachers, are designed to differentiate application roles according to real-life activities. Users in each group may communicate and exchange information from various physical location if their devices are within AP signal coverage. Learners may also have virtual discussion under different topics, and could send queries to educators for further information on materials. These questions are forwarded to Cloud, and processed by Processing Units (PU) afterwards. Following this, questions will be forwarded to recipients, and answered by teachers. Any requests or responses made by any users will be collected by Cloud. Unlike other methods, this learning technique will not only motivate students but also will help to reduce the cognitive load.

B. TECHNOLOGY SELECTION

The technology selection is a crucial part of an efficient system. There are several challenges that need to take into

TABLE 1. IMMS internal consistency.

Scale	Reliability Estimate (Cronbach's Alpha)
Attention	0.8
Relevance	0.81
Confidence	0.82
Satisfaction	0.8

account while selecting a technology such as Data Rate, Coverage, Mobility Support, Latency, Reducing Energy Expenditure, Unlicensed Operating Band and so on [18]. As WiFi is a prominent available technology which counteracts all the aforesaid challenges, we consider it in our system. For further details of the technology selection process, we refer the readers to [18].

V. RESEARCH METHODS

We applied a sequential mixed method research design that had been initiated with quantitative approach and followed by the qualitative approach. Two quantitative research data set and one qualitative research data set were collected to investigate student motivation, level of cognitive load and their opinions on the use of the newly developed instructional tool.

A. PARTICIPANTS (PR)

Participants were students from an English fundamental course, whose content includes grammar component. Students enroll the course through an open registration, then a randomization is applied. One group of 30 students, consisting of 9 males and 21 females, were recruited as the participants. Furthermore, these course members, on average are 21 years old, are currently undergraduate students from various faculties.

B. RESEARCH INSTRUMENT

Four research instruments were used in this study namely 1) Instructional Materials Motivation Survey (IMMS), 2) Cognitive Load Questionnaire (CLQ), and 3) a Semi-structured interview.

1) INSTRUCTIONAL MATERIALS MOTIVATION SURVEY (IMMS)

IMMS was employed to provide quantitative means of evaluating student motivation on instructional design of grammar learning tool which consists of 23 items which utilize . These items are grouped into 4 different criteria.

2) COGNITIVE LOAD QUESTIONNAIRE

Cognitive load questionnaire (CLQ) is a cognitive load measuring instrument, which utilizes 5 semantic scale starting from ''very high'', ''high'', ''normal'', ''low'' and ''too low''. There are 6 items adapted in this study for measuring CL. The first 2 items are used to measure Intrinsic Load (IL) which indicates the activity required more mental demand or engagement and the concepts are complex. The next 2 items are used for Extraneous Load (EL) which can be found when inspecting difficulties of instructional design, and ineffectiveness of instructional illustrations. Finally, the last 2 items were used for Germane Load (GL) to evaluate which activity that enhances learner's knowledge and performance.

Correlational analysis was done in order to investigate the relationship between motivational outcomes with cognitive load of the students. The analysis is important to know the impact of motivation on the cognitive load since the present study focuses on the motivation as factor to effect on the learners mind workload. In order to doing the correlational analysis, we used the SPPS software version 16.0 where the mean of the total motivational outcome (IMMS) and overall cognitive load (CLQ) were two variables.

3) SEMI-STRUCTURED INTERVIEW

Semi-structured interview was conducted to gather students' opinions, which are not directly observed through the quantitative data. Therefore, a follow-up qualitative study was employed to investigate in-depth characteristics and variation of motivational issues with relation to utilization of instructional tools in self-guided e-learning activities. The interview basically looked at: (1) student motivational attitudes, and (2) instructional design difficulty.

VI. RESEARCH FINDINGS

The findings are presented according to the research instruments: 1) IMMS, 2) CLQ, and 3) the interview.

A. INSTRUCTIONAL MATERIAL MOTIVATION SURVEY (IMMS)

The IMMS data demonstrate the motivational attitudes of the students towards the e-grammar learning tool. In this instrument, we analyzed the total outcome of IMMS according to gender, followed by criteria-based outcome. Then, we run an independent t-test to investigate the differences of total IMMS outcome between male and female, and finally, considered the item-based result of the IMMS instrument.

Gender-based result is aimed to know if a significance difference between the male and female populations in their motivational attitudes towards the deployment of the tool. Table 2 shows that females have higher motivational outcome ($m = 3.89$, $SD = 0.09$) than the male students ($m = 3.68$, $SD = 0.09$).

TABLE 2. Descriptive findings of IMMS based on gender.

Gender	N	Mean	Std.Deviation	Std.Error Mean
Male	9	3.68	0.03	0.016
Female	21	3.89	0.049	0.049

Table 3 illustrates the criteria based outcome (i.e., attention, relevance, confidence, satisfaction) of the IMMS differentiating between male and female students. We measured each criterion to justify whether it is standard or fluctuating between two genders. Then, Independent T-test was

TABLE 3. Criteria based motivation outcome of IMMS.

Gender	Male (Mean)	Female (Mean)
Attention	3.73	3.77
Relevance	3.66	4.01
Confidence	3.66	3.92
Satisfaction	3.68	3.88

performed to analyze the score difference in IMMS between male and female populations. According to table 4, there is a significant difference beween female (m = 3.89, SD = 0.03) and male (m = 3.68, SD = 0.09) outcome. Additionally, the test produced t = −4.05, df = 6, p = 0.00 i.e., $p < 0.05$ (two-tailed).

The results from the instrument (IMMS) illustrated in the table respectively 2, 3, 4 represents the validity of the objective of the study to enhance motivational nature of the students (i.e., male m = 3.68 and female m = 3.89). The analysis is important since it represents that students in both gender feels the instructional design motivational, and thereby improves their learning experiences.

B. COGNITIVE LOAD QUESTIONNAIRE (CLQ)

We focused the data analysis at three level, i.e., criteria-based result, gender based result, total cognitive load outcome, and an independent y-test of total the cognitive load. Correlational analysis was run to correlate the IMMS outcome with the CL of the learners after using the e- learning tool.

Table 5 shows mean scores of three types of cognitive load, namely intrinsic load (IL), extraneous load (EL) and germane load (GL).

It is observed that the students have low IL (m = 2.35, SD = 0.95); EL (m = 2.91, SD = 0.79); and GL (m = 3.50, SD = 0.68). From this outcome, it is evident that student find the activities less complicated, learning content is not difficult to understand and the presentation of the instruction could free up the working memory (due to low extraneous load) to increase germane load.

Gender based outcome of CL represents that males have higher overall cognitive load than the females. Here, males scored CL higher (m = 1.93, SD = 0.60) than females (m = 1.87, SD = 0.65) (as shown in Table 5).

The next analysis on cognitive load is independent T-test of total Cl to investigate whether there is a significant difference in CL outcome between male and female students. As provided in table 7, the independent T-test illustrates no significant difference in CL for male (m = 1.93, SD = 0.60) and female (m = 1.87, SD = 0.65) with t (0.28) = 0.22 and $p < 0.82$ (two tailed).

The outcome of this instrument (CLQ) highlighted in the table 5, 6, 7 reflects the objective of the study to manage the three cognitive loads, namely intrinsic, extraneous and germane. The overall mean is low in CLQ. It proves that exploiting the multimedia principle with CTML theory can manage cognitive load.

C. CORRELATIONAL ANALYSIS

The aim of correlation study was to investigate relation between the motivational nature and cognitive load of the students on using the e-grammar learning tool. The relation implies that the impact of the instructional design on motivational outcome affects cognitive load of the students. The findings of the correlational analysis demonstrated that students with low motivation had high cognitive load and vise-versa. The findings herein show that there is a significant strong negative correlation between students' total CL and motivation (r = -0.81, p = 0) which signifies that students who had higher motivation, they rated less cognitive load.

The scatter plot (Fig.5) also illustrates the linear relationship between motivation and cognitive load where r2 = 0.65 that signifies a decent model of the correlation of the two variables.

D. SEMI-STRUCTURED INTERVIEW

A semi-structured interview was conducted with 7 students on a voluntary basis. The objective of the interview is to identify the interest, importance and motivational attitudes of the students. In respect to motivational outcome, students have pointed that the design is able to teach grammar with creativity.

PR1: The tool is interesting because it teaches grammar interestingly with creativity. It also motivates the students since nowadays different applications are used to learn English grammar.

PR2: Actually, the tool is really interesting because the design, types of games, exercises are well combined. I think this type of tool having games and animations are demanding and helpful to improve knowledge on English grammar.

TABLE 4. Independent T-test result of IMMS.

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	T	df	Sig. (2 tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal Variances Assumed	2.3	0.17	-4.05	6	0.00	-0.21	0.05	-0.34	-0.08
Equal Variances Not Assumed			-4.05	3.6	0.01	-0.21	0.05	-0.36	-0.06

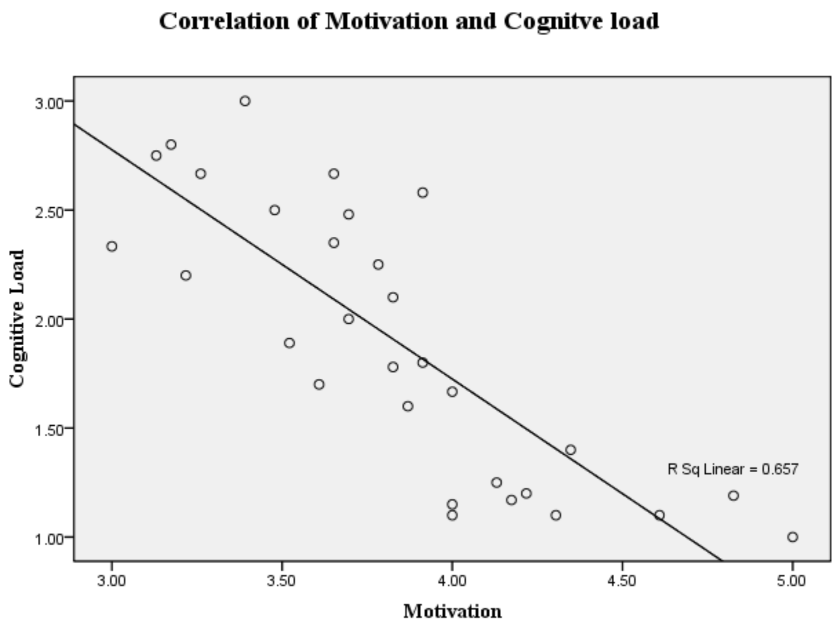

FIGURE 5. Correlation of motivation and cognitive load.

TABLE 5. Criteria-based CLQ outcome.

Types of Cognitive Load	Mean	Std.Dev
IL	2.35	0.95
EL	2.91	0.79
GL	3.5	0.68

TABLE 6. Gender-based outcome of the total CL (n=30).

Group	N	Mean	Std.Deviation	Std. Error Mean
Male	9	1.93	0.60	0.20
Female	21	1.87	0.65	0.14

Students also loved the exercises with feedback system. Feedback is essential to build up confidence in students. It aids to achieve the goal and also act as reinforcement for success. Thus, ultimately they enhance the learning capacity. Though some answers are negative in term of exercises where some of the students wanted more exercises.

PR3: So exercises must be increased the tool does not create any overload on our brain. I am very happy to use this tool and really it is helpful for improve English knowledge.

PR4: It is not boring even but the exercises in the tool need to be more with correct answer.

The second aim of the study is to inspect the cognitive load of the students since cognitive load has vital role in learning effectiveness. Most of the student gave their positive opinion about the design and presentation of the learning content.

PR5: The design is interesting and thus creates no boring to me.

PR6: The designs of this tool are well organized because too much use of effect creates any design complicated. But this tool is easier to use and looks attractive.

Therefore, it is assumed that the tool is able to motivate the students and managed their cognitive load.

VII. SIMULATION RESULTS

A. SETUPS

In order to evaluate how well our proposed smart communication network enabled grammar learning system, we perform simulation under NS-3 with following details

1) Wi-Fi 802.11n 2.4GHz technology is used to facilitate data uploading and downloading between user devices and teacher devices. All students and teacher are connected to green AP (left side), and orange AP (right side), respectively.
2) Each AP is connected to main processing unit using reliable medium with CSMA channel. The medium has 100Mb/s capacity.
3) Green and orange AP operates on different channel and SSID.
4) Both teachers and students have mobility feature within each AP coverage. These devices may walk in random direction.
5) Each students subscribe to all courses, and choose it randomly. Therefore, one student produces one traffic flow for the topic at random time. Each flow is allocated based on student id and teacher id. If there are 3 teachers and 10 students, then student 1, 2, 3 will follow lesson provided by teacher 1, 2, 3, respectively. Moreover, student 4,5,6 will subscribe to lesson provided by teacher 1,2,3. At some point, flows can not be evenly distributed.
6) Each flow has packet size of 10KB and runs on UDP Socket. This packet has similar size of packet in chatting application.

TABLE 7. Independent T-test outcome of total CL.

	F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	0.81	0.37	0.22	28	0.82	0.05	0.25	-0.46	0.57
Equal variances not assumed			0.23	16.24	16.24	0.82	0.24	-0.46	0.58

7) Packet transmission and standby time are random with mean value of 0.01 and 0.05 seconds, respectively.
8) UDP Protocol is incorporated in the simulation to facilitate end-to-end communication.

B. RESULT

We monitor each flow within the system in terms of delay, and jitter. One flow can be illustrated as one transmission with unique combination of source and destination IP address. In our setup, we varies number of flows for different number of student and teacher. As seen on figures below, there are up to 80 students that send message to 1, 5, or 10 teachers in each setup. Additionally, each flow may occur several times according to packet transmission interval. After running several scenarios, average value of these metrics is calculated and illustrated in Figure 6, and 7.

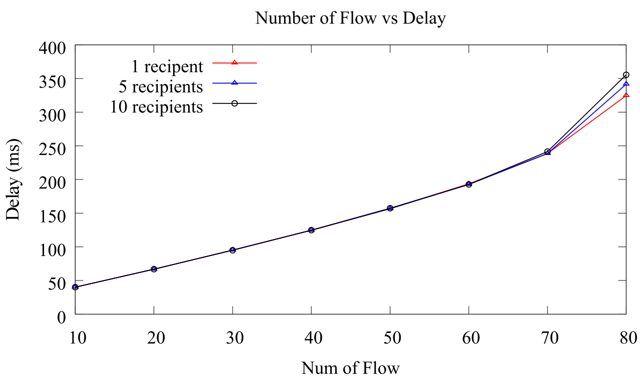

FIGURE 6. Average delay.

Delay is calculated by subtracting packet transmission time from reception time. Each flow will have its random packet transmission time that follows exponential distribution. As seen on Figure 6, average packet delay decreases along with the increase of number of flows. This is due to the condition that more packet is being transmitted and less successful flows (Figure 8).

$$\text{loss rate} = \frac{\text{num of loss packets}}{(\text{loss packets} + \text{received packets})} \tag{1}$$

Further investigations have been made on loss rate and non-zero flows made by all students. Loss rate is derived from the equation 1, while non-zero flows is obtained by counting the number of flows that have at least 1 packet received

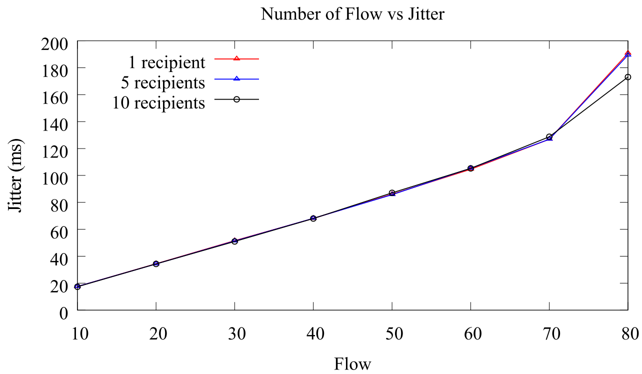

FIGURE 7. Average jitter.

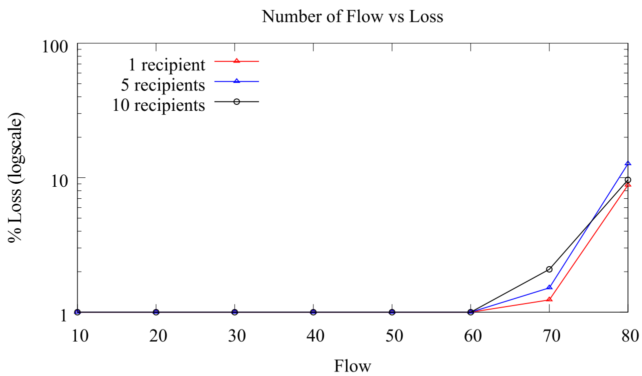

FIGURE 8. Average loss.

at destination. As seen on Figure 8, the system starts to lose its packets starts from 80 flows. At this point, 1,5, and 10 teacher configuration receives 80, 16, and 8 different packet senders. Medium capacity condition whenever student's AP receives and teacher's AP transmits the packets has reached its limit at this point forward. The AP is unable to find enough time to transmit the packet.

Meanwhile, according to Figure 9, increasing the number of nodes can not increase the number of non-zero flows. The maximum flows that can be handle by the system configuration is 70. Any bigger number than this will make the performance degrades.

VIII. DISCUSSION

This section deals with the importance of smart communication network enabled e-grammar learning system and its effectiveness on motivation-cognitive load issues of

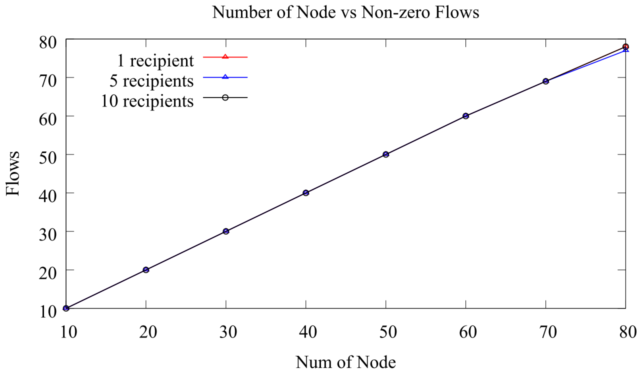

FIGURE 9. **Number of non-zero flows transmission.**

the students. The proposed system was developed in order to facilitate the technology that exploited the multimedia for instructional design. Central to this system is the importance of the proposed network for second language learners to develop meaningful learning activities. For the second language users, it is inevitable to introduce new grammatical components by means of grammar learning system. Therefore, development of the proposed learning system was also a significant contribution to the present language learning practice. The system also contributed to the other factors related to meaningful learning. The outcome of the instructional design was effective to motivate learners to use the most advanced technology for grammar learning as well as the instructional design helped them to manage the overall cognitive load due to the presentation and subject difficulty of the learning materials.

The findings of IMMS and CLQ demonstrated that students were motivated as the overall cognitive loads were low. It was also observed that students scales satisfying in IMMS (motivation measuring scale) and cognitive load questionnaire. Correlational analysis found a negative strong relationship between motivation and cognitive load where interview expressed the positive impression of the students about the tool. The students believed that e-grammar learning tool has been able to motivate them and manage their cognitive load low.

The findings of the first instrument for motivational nature of the students (IMMS) revealed that e-grammar learning tool had a positive impact on learner motivation. It was noticed that the e-grammar learning system exploited the smart communication network by integrating (motivational and cognitive approach based) it into the instructional design, and this was able to gain attention, bring relevancy in learning materials which lead them to have confidence and ultimately satisfy them. The implementation of the ARCS model has made the instruction design equally attractive; for example, illustrations relevant to the real context; all the feedback process, rewarding to the completion of the levels of modules builds up the confidence and finally satisfy them in a standard level. The data established the suitability of applying the model for the development of instructional design of e-grammar learning tool. In comparison to other studies [30], [37] and instruction design [38], [39] which applied ARCS model for designing learning instructions for motivating different level of learners, it was evident that the application of the ARCS model is able to improve motivation level of the students in learning experiences.

The findings of the CLQ showed that students had lower cognitive load after using the proposed tool for grammar learning. The result of this study is similar to other study who also measured the different kinds of cognitive load to know the impact of a technology enhanced tool [40]. To analyze the result of this current CLQ outcome, it is necessary to show the reasons. Firstly, exploiting smart communication networks has a positive impact on improving access of the learners to meaningful learning activities [41], [42]. The studies investigated the impact of the proposed network based solution to enhance learning process that positively encouraged the students' motivation to learn as well as enhancing learning performances. Secondly, real-life implementation of [43] proved that multimedia-based instructions made learners understand instructions more easily. This is because multi-channel of sensory-memory works together to organize and integrate information for long-term memory Thirdly, the instructional design with CTML is one of vital issues that effectively influences cognitive systems of learners. However, in order to achieve this, theoretical foundations for presenting instructions properly are mandatory beforehand [15]. Therefore, all three mentioned aspects simultaneously worked on managing the cognitive load on the learners.

Considering the third instrument, semi structured interview, we find a positive attitude of the students who says the tool is been interesting to use and helps to enhance knowledge on English grammar. Few students are exceptional but most of the students claimed the tool motivational and learning effective.

IX. CONCLUSION

In this work we have investigated development of smart communication networks for an e-grammar learning system that embeds the ARCS motivation model and CTML model. In order to stimulate and sustain learner motivation, different types of audio visual instructions have been included in this system. The findings of the study have confirmed that the proposed system can greatly motivate the learners at a greater scale. Overall through the proposed system, we have observed that for a given workload, the students have been exposed to overall less cognitive load and the correlation result of motivation and cognitive load has significantly been negative. The findings have supported the aim of the study to design and implement an e-grammar learning tool to enhance motivation and optimize the learning load from the learner's mind.

From the educational perspective, the present work has contributed to extend the implementation of motivational theory over the context of e-grammar learning. The motivational model aims to help the students actively participate in learning. Through the implementation of the ARCS motivational model in instructional design of grammar learning, the student can be more actively involved in learning activities, which can be beneficial from both the collaboration and academic performance. Moreover, the uses of a variety of feedback systems through exercises, practice, illustrations of real world examples can empower the comprehensive knowledge gained by the students. In addition, the daily conversational examples can assist learners in establishing connection between prior knowledge of the learners and future importance of the concept. Through e-grammar learning exploiting the motivational model, learners can build up the notion of self-control of using appropriate language in the right context.

The second issue highlighted in this work was enactment of the CTML for instructional design of an e-grammar learning tool. As earlier, it was depicted that the available online tools for grammar learning are quite static, having no variation of multimedia properties as well as no rigorous theoretical foundation. The proposed instructional design has aimed to overcome the existing gaps on multimedia exploitations for the e-grammar learning tool.

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NADIA REFAT is currently pursuing the Ph.D. degree with the Center for Modern Language and Human Sciences, University Malaysia Pahang. Her main areas of research interests include technology-based learning and social networking.

MD. ARAFATUR RAHMAN received the Ph.D. degree in electronic and telecommunications engineering from the University of Naples Federico II, Naples, Italy, in 2013. He was a Postdoctoral Research Fellow with University of Naples Federico II, in 2014, and a Visiting Researcher with the Sapienza University of Rome, in 2016. He is currently a Senior Lecturer (equivalent to Assistant Professor) with the Faculty of Computer Systems and Software Engineering, University Malaysia Pahang. He has coauthored over 60 prestigious IEEE and Elsevier journal and conference publications. His research interests include the Internet-of-Things (IoT), wireless communication networks, cognitive radio networks, and vehicular communication. He has developed excellent track record of academic leadership as well as management and execution of international ICT projects that are supported by agencies in Italy, EU, and Malaysia. He is a Fellow of the IBM Center of Excellence, Malaysia. He has received a number of prestigious international research awards, notably the Best Paper Award at ICNS'15 in Italy, the Best Masters Student Award, and the ITEX'17 Awards in International Exhibitions in Malaysia and iENA'17 in Germany. He has served as the Publicity Chair, the Session Chair, and a Program Committee Member of the Technical Programme Committee (TPC) in numerous leading conferences worldwide.

A. TAUFIQ ASYHARI received the B.Eng. degree (Hons.) in electrical and electronic engineering from NTU, Singapore, in 2007, and the Ph.D. degree in information engineering from the University of Cambridge, U.K., in 2012. He held academic and research positions at the University of Bradford, U.K., National Chiao Tung University (NCTU), Taiwan, and Bell Laboratories, Stuttgart, Germany. He also held visiting appointments at Telkom University, the University of Stuttgart, and the NCTU Information Theory Laboratory. He has been a Senior Lecturer in Internet of Things with Coventry University, U.K., since 2018, where he is currently with the School of Computing, Electronics and Mathematics. His research interests include information theory, communication and coding theory, and signal processing techniques with applications to wireless and molecular communication networks, the Internet of Things, and data analytics.

Dr. Asyhari is a Fellow of the Higher Education Academy, U.K., and a member of the IEEE Information Theory Society. He was a member of the Technical Program Committee in a number of leading international conferences. He received the notable Samsung Global Research Outreach Award, in 2017, the Silver Medal at the International Trade Fair iENA 2017, the IEEE–EURASIP Best Paper Award at the 11th IEEE–ISWCS 2014 in Barcelona, Spain, the National Science Council of Taiwan Starting Grant, in 2013, and the Cambridge Trust–Yousef Jameel Scholarship for his Ph.D. study. He currently serves as the Demo/Poster/WiP Chair for the IEEE DASC 2018 in Greece and was the Session Chair of the IEEE SSCI 2016 in Greece and the IEEE ISIT 2013 in Turkey. He has been frequently invited to review articles in prestigious journals and conferences. Since 2018, he has been an Associate Editor of the IEEE ACCESS journal.

IBNU FEBRY KURNIAWAN is currently a Lecturer with the Department of Informatics, Universitas Negeri Surabaya. His main research interests include distributed computing, cyber-physical systems, and security.

MD. ZAKIRUL ALAM BHUIYAN received the M.Sc. and Ph.D. degrees (Hons.) in computer science and technology from Central South University, China. He was an Assistant Professor with Temple University. He is currently an Assistant Professor with the Department of Computer and Information Sciences, Fordham University, USA. He has authored/coauthored over 110 publications, including prestigious journal/transaction articles, conference proceedings, book chapters, and two books. His research interests include dependability, cybersecurity, big data, and cyber-physical systems. He is a member of the ACM. He has served as the General Chair, the Program Chair, the Workshop Chair, the Publicity Chair, a TPC Member, and a Reviewer for various international journals/conferences. He has also served as an Associate Editor and a Lead Guest Editor for key journals, including IEEE the TRANSACTIONS ON BIG DATA, the *ACM Transactions on Cyber-Physical Systems*, the IEEE IOT JOURNAL, INS, FGCS, IJCA, and *Cluster Computing*.

HAFIZOAH KASSIM received the Ph.D. degree in educational technology. She has over 18 years of experience in the field of language education and almost 12 years of experience in the field of creativity and cognitive studies. She is a keen Researcher and a Writer specializing in emergent technologies in language education, creativity, and cognitive studies, English for specific purposes, multimedia learning, and learning styles. She is currently a Senior Lecturer with the Centre for Modern Languages and Human Sciences, University Malaysia Pahang.