Pedagogical and E-Learning Techniques for Quality Improvement of ICT Education

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Additional information is available at the end of the chapter

Abstract

This chapter elaborates how the pedagogical and e-learning techniques are useful in enhancing the quality of Information and Communication Technology (ICT) education in developing countries. From the literature review and outcomes of other surveys, it was proven that the pedagogical techniques are one major missing component of an ICT education system in developing countries, including Sri Lanka. To raise the quality of ICT education, this study has developed a prototype model to increase the usage of pedagogical techniques and digital learning environment in the ICT education activities. The proposed model is designed with six activity levels. Each level in the model is aligned with the levels of Bloom's taxonomy and other pedagogical techniques, which is embedded in the levels of Bloom's taxonomy. The model was validated by a panel of teachers and was tested in the school environment too. The validity of performance was proved using six hypothesis tests and other methodologies. The analysis shows that the students' performance in problem solving has increased by 19.5% due to the different treatment levels used. It was also proved that the embedded techniques (mixture of traditional and modern pedagogical methods) are more effective in skill development of students compared with the existing context.

Keywords: pedagogies, Bloom's taxonomy, e-learning, quality, ICT education

1. Introduction

Information and Communication Technology (ICT) applications, in particular with the education system, might change the future of the underdeveloped world, eliminating the digital divide from the education system both locally and in the international arena [1]. However, there are some challenges that the developing world faces in trying to adopt ICT to the education

sector. These challenges relate to: limitation of funds, Internet access, lack of trained staff, hesitation to change to new technologies and policy inadequacy. Several researchers and educationists have suggested that ICT would be an important part of education for the next generation.

Modern technology offers many means of improving the teaching and learning process in the classroom. In comparison to developed countries like UK, USA, Singapore, etc., ICT skills of students in developing and developed countries, including Sri Lanka, show no comparative improvement as evident in the school system. Based on experiences gained in developed counties as well as with instructions and guidelines of local and international experts, responsible implementers have carried out several activities to enhance ICT education. Yet, no combative significant improvement has been reported regarding ICT education.

ICT is a major ingredient for rapid development and should be implemented through the school platform. As such, researchers are keen to explore how this could be done. Considering the abovementioned facts, investigating the quality improvement and exploration of research possibilities of ICT education in the Sri Lankan educational system is considered appropriate because Sri Lanka is a rapidly developing country in Asia. This study elaborates on a researchable framework toward improvement of quality ICT education. It utilizes existing resources while improving the methodologies along with pedagogical techniques and e-learning approaches used in the secondary schools of Sri Lanka.

2. Importance of ICT for the teaching, learning and evaluation (TLE) process

The strategic role played by Information and Communication Technology (ICT), nowadays, is undisputed as ICT has merged with almost all of our day-to-day activities. ICT has paved the way to be informed, keep abreast and contribute toward evolving technology as well. ICT has made inroads to almost every sphere resulting in a heavier burden on education as both the current and future workforce need to be well-equipped to meet the demands of the communication age. It is education that has to play a major role toward the supply of high quality and skillful professionals capable of handling both present and future needs. Current trends make it imperative for higher education in the country to seriously think about and if necessary, completely overhaul, if the country aspires to make revolutionary changes in development. The message seems to have gained ground and ICT education has received prominence with the education process.

The quality of higher education or improvements of a school depends on dimensions such as quality learners, quality learning environments, quality content, quality processes and quality outcomes [2]. The effectiveness of the teaching and learning (TL) process consists of five subprocesses such as curriculum design, pedagogical design, implementation quality, outcomes assessment and resource provision [3]. Pedagogical design is an important component in these subprocesses, and it is an independent factor regardless of the standard design of higher education or school education where pedagogical techniques are easily adopted by the educational communities [3]. Contemporary definitions describe pedagogy as the art, profession or science of teaching. Accordingly, pedagogy can be defined as an effective way of

describing the relationships between teaching, learning and assessment in classrooms [4, 5]. There is also a belief that to talk of pedagogy is to talk of the appropriate ways teachers interact with learners.

2.1. Pedagogy

There is no accepted universal ultimate model for effective pedagogy or quality teaching, learning and evaluation (TLE). The ultimate outcome expected from a quality TLE process is to enrich students with an expected level of skills regarding cognitive, affective and psychomotor quantifiers against the expected skill levels of the course unit or educational program. Traditional definitions describe pedagogy as either science/theory or art/practice of the TLE process that makes a difference related to the cognitive, affective and psychomotor levels of students. New pedagogies can be defined concisely as new models of TLE partnerships between and among students and teachers. The aim is to achieve deep learning skills. The goals require making use of prevalent digital access through various technologically innovative digital tools.

Studies on pedagogy reveals that pedagogical talents will provide much support toward actuation of TLE skills required to face the changes in TLE process in the twenty-first century. Educational experts also recognize that the majority of transmission or knowledge delivering processes is highly ineffective for the twenty-first century as against the expected competencies and skills of learners [4]. However, it is experimentally and practically provided that learners need skills such as critical thinking, innovation capabilities, ability to communicate efficiently and effectively, problem solving abilities through negotiation and collaboration, and so on. Therefore, pedagogical involvement of the TLE process is a vital component of a skills development process of learners. Accordingly, TLE process should be embedded in the new pedagogical techniques toward achieving student outcomes with expected skills. This can be done through digital accesses with new tools and technologies related to ICT [4].

2.2. Importance of pedagogy

Many countries in the world still remain economically poor. This affects their technological status. It can be argued that various reasons contribute toward poverty and economies. As such, there is an imbalance between the economic situation and technological aspects. This imbalance, in turn, will directly affect the quality of an education system leading to a digital included [5]. Among countries and within a country, there are disparities, province-wise, district-wise and rural and urban situations too. Whereas in some parts of the world, ICTs are contributing to revolutionary changes in the development process, in other parts of the world, the lives of people have hardly been touched by these innovations. Therefore, by providing such facilities at a reasonable level, the development process of developing countries or poor, can be enhanced and isolation from new inventions can be minimized up to some extent.

As discussed earlier, most ICT experts and educationists recommend that ICT technology can be used to minimize the digital divide in different situations. It is an undisputed fact that future economies and even potential for innovations with technology of any country would depend on the quality of education provided [6]. When one discusses quality education, one

of the key ingredients toward quality education is pedagogy. To achieve quality education, pedagogical techniques need to be incorporated with the TLE process, in addition to other factors such as human resources (teachers and other resource persons, etc.) and physical resources (classroom facilities, labs, computers and multimedia devices, etc.).

Toward providing deep learning skills to the student community, first, the teachers should have skills with deep learning activities [7]. To equip teachers for this purpose, this chapter provides an experimental model for teachers to accrue deep learning skills and means to transmit the gained knowledge to the student community. This is to be done through an activity-based learning environment incorporated with ICTs. The process for the proposed model is based on a pedagogical innovation platform. It is arranged in the following ways: (1) through classroom training and practices with innovative pedagogical techniques using interactive ICT techniques and e-facilities (both teacher-directed and self-regulated learning), (2) participating in and practicing with pedagogical innovation techniques through professional learning communities and (3) implementing stages (1) and (2) with students in the school environment.

2.3. ICT education and pedagogy

Subject matter and pedagogical training are important concepts in the design of teacher training programs [8]. It is apparent that most ICT teacher training programs in developing countries lack a robust theoretical framework [9]. It is imperative for ICT teaching and learning methods and methods of teacher training to blend meaningfully toward maintaining quality with ICT education. Therefore, pedagogical techniques have to be embedded in ICT training programs to obtain expected outcomes [10]. Quality methods related to teaching and teacher
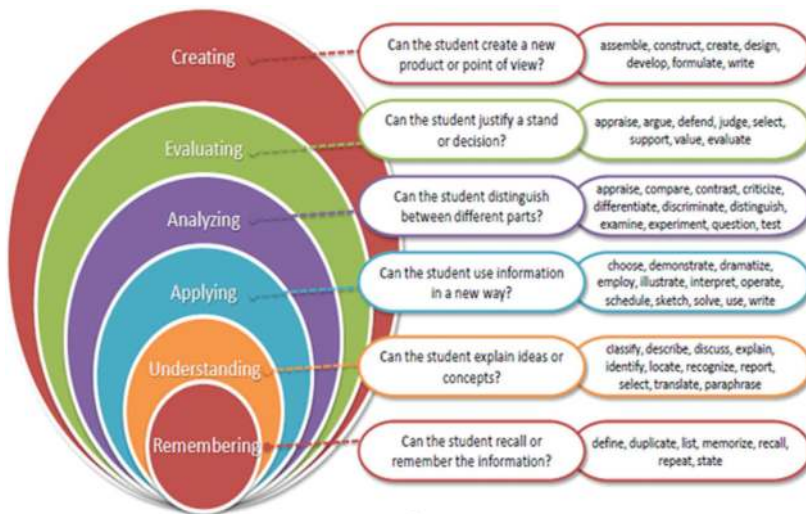

Figure 1. Revised Bloom's taxonomy (source: http://pcs2ndgrade.pbworks.com/w/page/46897760/Revised%20Bloom's%20 Taxonomy (last accessed on 02/03/2017)).

training are essential to achieve the learning outcomes maintained in international quality standards. One of the internationally accepted quality educational methodologies of teaching and learning is Bloom's taxonomy. However, other pedagogical techniques can also be used for the development of quality ICT education.

2.4. Quality enhancement with Bloom's taxonomy

Bloom's taxonomy is considered an internationally accepted quality educational pedagogy for teaching and learning. An exploration of the theoretical foundation of the revised Bloom's taxonomy reveals that the levels of learning and similar useful and appropriate verbs (as shown in **Figure 1**) of the revised Bloom's taxonomy can be used to implement quality teaching and learning processes.

Developed countries use pedagogical methodologies [4] like Bloom's taxonomy to enhance the quality of their teaching and learning processes.

3. Digital learning environment (e-learning)

The digital learning environment is a successful technique to acquire required skills and knowledge with teacher training programs [11] as well as in the students' learning paradigm [12, 13] in the modern world. In this era, ICT education and general education are equipped with a digital learning environment [13, 14]. An examination of the literature on ICT for education reveals that the quality of one's education tends to improve particularly through continuing existing face-to-face learning and distance education which is also called blended learning [2, 15]. Blended learning refers to the design and delivery of right content in the right format using the right mix of media. It combines online digital media with traditional classroom methods requiring the physical presence of both teacher and student, with some element of student control over time, place, path or pace.

In the last three decades, there have been great changes in the education landscape of economically advanced countries. For example, increasing access to education has resulted in the diversification of student populations that have a wide range of learning styles and learning needs which are quite different from the traditional and elitist student populations. At the same time, education institutions are asked to respond to the demands of globalization and the knowledge economy, to prepare students with twenty-first century skills and competencies for the labor markets, which require changes in the curriculum and teaching practices. There are demands for increased efficiency, more transparent accountability and better performance in both research and teaching. Some policy makers see digital technology as a tool to help manage some of these changes, and in particular, to use it as a transformative tool in teaching and learning [16]. Further, developed economies use the blended approach, whereas in developing countries, its usage is minimal [1]. Therefore, by introducing blended learning approaches to the teaching and learning paradigm, quality education and ICT education can be achieved [16]. Accordingly, blended learning techniques [e-Books, Learning Management Systems (LMS) activities, e-discussion forum, etc.] are highly useful techniques for the achievement of quality with education.

4. Important learning methodologies and other pedagogies

Literature reviews reveal that activity-based learning and problem-solving activities are greatly contributing toward the enhancement of ICT education in schools [10, 17]. Further, other pedagogical techniques like Kolb's excremental reflective learning model [18, 19], facial expression and emotional models also contribute highly toward the quality of education in the teaching, learning and evaluation process [18].

4.1. Activity-based and problem-based learning

Activity-based learning is a comprehensive approach for classroom teaching and learning that is designed to engage students in investigation of authentic problems [8]. Activity-based learning provides goals mastery versus ability, learning versus performance and task versus ego involvement [8]. Further, activity-based learning has a higher probability of producing greater achievement than the non-manipulating lesson [18]. Problem-based learning through activities highly increases the enthusiasm of the students due to the following reasons: involvement of students in problem-solving authentic problem and in working with others and building real solutions with the use of new technological innovation. Problem-based learning through activities have a high potential to enhance deep understanding because the student needs to acquire and apply information, concepts, principles and they have the potential of improving competence in thinking (learning and metacognition) because students need to formulate plans, track progress, and evaluate solutions [8].

4.2. Kolb's experiential learning circle

Kolb's experiential learning circle could provide much support toward the educational development process in several situations [19]. **Figure 2** shows the four-stage process of Kolb's experiential learning circle.

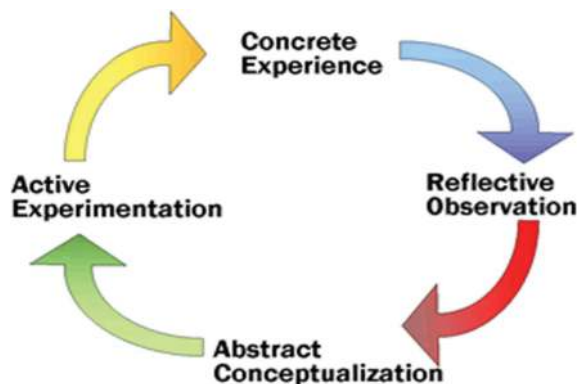Further, Kolb's experiential learning theory [17] described as follows:

Figure 2. Kolb's experiential learning circle (based on [17]).

Stage	Description
Concrete experience (CE)—DO	Where the leaner is actively experiencing an activity (e.g., a laboratory session, field class)
Reflective observation (RO)—OBSERVE	Where the learner is consciously reflecting back on that experience
Abstract conceptualization (AC)—THINK	Where the leaner is being presented with/or tries to conceptualize a theory or model of what is (to be) observed
Active experience (AE)—PLAN	Where the learner is trying to plan how to test a model or theory or plan a forthcoming experience

Table 1. Kolb's experiential learning circle [11].

Stage	Description	Activities to help
Concrete experience	Kolb's cycle starts with a concrete experience. In other words, it begins with doing something in which the individual, team or organization is assigned a task. The key to learning, therefore, is active involvement. In Kolb's model, one cannot learn by simply watching or reading about it, to learn effectively, the individual, team or organization must actually do.	Laboratory experience, reading, team games, problem solving, discussion, practical exercises, field work.
Effective observation	The second stage in the cycle is that of reflective observation. This means taking time-out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage, lots of questions come out from "doing" and stepping back from the task and reviewing what has been done and experienced. At this stage, lots of questions are asked and communication channels are opened to other members of the team. Vocabulary is very important and is needed to verbalize and discuss with others.	Ask for observation, write a short report on what took place, give feedback to other participants, brainstorming sessions, rhetorical and thought questions, completing learning logs or diaries.
Abstract conceptualization	Abstract Conceptualization is the process of making sense of what has happened and involves interpreting the events and understanding the relationships between them. At this stage, the learner makes comparisons between what they have done, by reflecting and what they already know. They may draw upon theory from textbooks for framing and explaining events, models they are familiar with, ideas from colleagues, previous observations or any other knowledge that they have developed.	Lecture, papers and present models give theories, facts, project and analogies.
Active experimentation	The final stage of the learning cycle is when the learner considers how they are going to put what they have learnt into practice. Planning enables taking the new understanding and translates it into predictions as to what will happen next or what actions should be taken to refine or revise the way a task is to be handled. For learning to be useful most people need to place it in a context that is relevant to them. If one cannot see how the learning is useful to one's life then it is likely to be forgotten very quickly.	Give learners time to plan, use case studies, use role play, ask learners to use real problems.

Table 2. Learning theory of Kolb's experiential learning cycle.

Concrete experience	Reflective observation	Abstract conceptualization	Active experimentation
Reading, examples, fieldwork, laboratories, problem sets, trigger films, observations, simulations/ games text reading.	Logs, journals, discussion, brainstorming, thought questions, rhetorical questions.	Lecture, papers, projects, analogies model building.	Projects, fieldwork, homework, laboratory, case study and simulations.

Table 3. Different learning aspects of Kolb's experimental learning circle [11].

Kolb's experiential learning cycle is the most widely used learning theory in experiential research due to its implementation feasibility with educational activities (**Table 1**). The abstract—basic principle of Kolb's reflective process for education development [20, 21] is shown in **Table 2**.

Table 3 summarizes the activities that support the different aspects [17] of Kolb's experiential learning circle.

4.3. The universal facial expression of emotion model

The universal facial expression of emotion model and stakeholders' feedback play a major role in quality evaluation in the teaching and learning paradigm [18]. Developed countries use evaluation of quality through facial behavior of teachers in teacher training programs as well as in implementing such programs in their schools. The universal facial expression model shows different stages of the facial expression of emotion model. The changes come in seven stages. The seven stages are: happy, surprise, contempt, sadness, fear, disgust and anger [18].

5. Importance of pedagogical techniques in ICT education and general education

It is believed that quality ICT education is dependent on nine factors [22, 23]. In this regard, national goals, country expectations, budget allocation, international benchmarks and standards related to quality ICT education such as (1) infrastructure facilities, (2) human resource facilities, (3) maintenance and sustainability plans, (4) software, (5) curriculum implementation facilities,(6) policy matters, (7i) support from the administration and supportive initiative, (8) research and development and (9) budget allocation and country expectations are considered essential factors toward quality with ICT education.

Further, the investigation reveals that pedagogical techniques greatly contribute to the maintenance of quality with ICT education [23] together with the nine quality factors mentioned. Therefore, to determine its application to the Sri Lankan context, a sample survey was conducted with the following sample.

In the sample survey, the following sources were used to collect the required information in connection with ICT education in Sri Lankan schools using three structured questionnaires. Thirty-five principals, 1295 students and 48 ICT teachers from 35 schools in five districts participated. In addition to this, a variety of stakeholders (e.g., Ministry of Education (MOE), National

Institute of Education (NIE), Universities and ICT experts in industry, etc.) in ICT education and different methodologies (classroom observation and workshops) were used in the survey. As fact gathering instruments, questionnaires, unstructured interview schedules, classroom observation sheets and workshop monitoring sheets were designed and used to gather information related to the pedagogical usage of ICT education in Sri Lankan Schools. It took more than 6 months for the data collection process in the sample survey that included both privileged and underprivileged districts. Random judgment sampling technique was used to select the sample.

The Kruskal-Wallis test on total ranks for usage of pedagogical techniques under the curriculum implementation facilities/technique on ICT teachers and principals' point of view is used to prove the attitudes toward the usage of pedagogical techniques for the implementation of ICT education. Used in the Sri Lankan ICT context, the results revealed to be very poor and lacking in many respects. The confidence interval for the mean and median also support the same. Based on the outcomes of the literature review and sample survey, it was concluded that there is a lack of pedagogical involvement in ICT education in developing countries, including Sri Lanka. Considering the abovementioned issues, the experimental application model was designed and implemented under a test environment to minimize the lack of pedagogical usage and incorporate the blended learning technologies into ICT education.

6. Experimental application model for enhancement of quality ICT education

The abovementioned exploration shows that there is a lack of pedagogical techniques and blended learning activities in the ICT educational development process in developing countries, including Sri Lanka. Further, it was highlighted that the quality of ICT education can be increased incorporating pedagogical and blended learning approaches to the teacher training programs and subsequently classroom teaching activities with students [23].

Toward enhancing the quality of ICT education, the following experimental model was designed and implemented on an experimental platform in selected schools in Sri Lanka. This model was tested in two stages. In stage 1, the implementation of the proposed experimental application model was with selected teachers (as training of trainers). With their feedback and other reflective aspects, the model was smartened. In stage II, the enhanced model was implemented in the school environment with the support of the trained teachers referred to above, and with their students. Based on their feedback and practical complications, the model was further smartened as appropriate. In designing the application model, the revised Bloom's taxonomy was used as the key methodology of the study and e-learning concepts, principles in Kolb's Experimental Learning Circle, activity-based learning, peer learning, and other theoretical and practical activities were used as supplementary techniques of the application model.

The experimental application model consists of six activity levels including the traditional face-to-face learning as activity level one besides other five activity levels. The other five activity levels cover one or two levels of the revised Bloom's taxonomy incorporating the other

techniques especially in blended learning activities with reflective practice where necessary. All the activities are designed to achieve the best possible outcome in the learning domains such as knowledge, attitude and skills.

The application model was developed by incorporating all the abovementioned theoretical aspects and validated with the practical implementation platform. Stage I was tested by an expert panel comprising an ICT domain expert, an ICT instructor and nine leading ICT experienced teachers through a series of face-to-face and e-learning activities inclusive of all the abovementioned activities and pedagogies.

In addition to the stakeholders' feedback and suggestions, the success of the model was evaluated using the implementation of the seven-stage facial expression model. Outcomes of the seven-stage facial expression model were used to smarten and fine-tune the experimental application model. Stage I also made use of two submodules that are as follows: (1) Sub Module 1: Master Teacher and Teacher Trainers' Model—initially master trainer implemented the abovementioned experimental pedagogical model with his/her trainers [hereafter referred to as: training of trainers (i.e., with the selected nine teachers)]. In implementing Sub Module I of Stage I of the Model, the master trainer provided facilities to use Sub Module II of stage I. (2) Sub Module II: Peer-to-Peer Learning Model: the main task of this submodule is to share or transmit knowledge among the different stakeholders using the application model to mitigate the knowledge gap. This model used peer learning activities through digital learning approaches like e-learning approaches, usage of learning management systems (LMS), discussion forum and reflection guidelines.

The second stage of this model was experimentally implemented by the nine trained teachers with 61 students from three different schools. The second stage too consists of two submodules: (1) Sub Module (III)—Trained Teacher-Student Model and Sub Module (4)—Peer-to-Peer student model. The implementation of Sub Module (3) and Sub Module (4) are similar to the implementation of Sub Module I and Sub Module II, respectively. However, the implementation of stage I is handled by a master trainer with teacher trainers (training of trainers), while stage II is implemented by the trained teachers with their students. This is the only difference. The implementation and final evaluation were based on the outcomes of students' activities carried out by the nine trained teachers referred to, abovementioned text, in three different schools with the help of the researcher. Finally, the proposed application model was further fine-tuned using the fundamental theory embedded in Kolb's Experiential Learning Circle when practiced in the school environment.

7. Sample presentation of the activity models

The proposed experiential application model consists of six activity models. The first activity model (Activity Level 1) includes the existing face-to-face traditional approach while the other activity model covers one or two levels of Bloom's taxonomy. Each activity model included other pedagogical techniques already discussed in addition to the e-learning approaches. As a sample approach, Activity Model 2 is represented as follows:

7.1. Activity Model 2

This sample Activity Model 2 covers the first level of Bloom's taxonomy (keywords are used according to similar verbs given in **Figure 1**) and it was implemented according to the guidance given in Kolb's Customized Reflective Learning Circle guidelines given in **Figure 2** and **Tables 1–3**.

7.2. Implementation of the second activity model of the proposed approach

This sample question is based on the first level of Bloom's taxonomy and it covers all four stages of Kolb's Experiential learning Circle in addition to other techniques.

Exercise 1.1. Define the basic data types used in Python programming language. List how different data types can be used to solve application with problem-solving activities. You may use simple examples to illustrate the answer.

The abovementioned exercises were introduced in four stages so as to provide comprehensive learning experiences to the stakeholders.

Stage 1: Activities in connection with concrete experience in Kolb's Experimental Learning Circle

  i. Provided lecture notes, e-materials, sample solved related questions.

 ii. Granted access to online help facilities with the Python programming language.

iii. Provided facilities for peer discussion to further strengthen individual answers.

Stage 2: Activities in connection with reflective observation in Kolb's Experimental Learning Circle

  i. Conducted brainstorming session in connection with the different data types in Python, their applications and how to apply these data types with activities related to problem solving with real life applications.

 ii. Provided environment to judge own solutions in connection with different data types and applications.

iii. Provided facilities to maintain a reflective log in connection to the outcomes to the question in activity model 1.

Stage 3: Activities in connection with abstract conceptualization in Kolb's Experimental Learning Circle

  i. Conducted a series of lectures in connection with the following methodologies: Bloom's taxonomy and its application, blended learning approaches (e.g., to use e-materials, educational websites, familiarizations with LMS and online courses) in connection with the data types and application in Python provided in the sample course materials.

 ii. Provided facilities to use stage 1 of Bloom's taxonomy in connection with data types and their application.

iii. Provided guidance to design learning activities using the first level of Bloom's taxonomy to achieve the learning outcomes. Guidance was given for the preparation of examination questions using the first level of Bloom's taxonomy.

iv. Provided facilities to discuss/create a forum on some important contents of programming and problem-solving activities through an online discussion forum making use of individual answers and explored possibilities to enhance the definition using e-materials in educational websites.

v. Provided facilities to conduct a rhetorical and thought question session related to covering the learning outcomes coming under the first level of Bloom's taxonomy.

vi. Provided facilities to use LMS activities in connection with activities and evaluation related to the different data types and problem-solving activities in Photon programming languages using the first level of Bloom's taxonomy.

vii. Provided facilities to discuss within peer-peer student groups and master teacher-student approach related to the first level of Bloom's taxonomy.

Stage 4: Activities in connection with the active experimentation in Kolb's Experimental Learning Circle

i. Provided a brainstorming session to encourage the use of Bloom's taxonomy, blended learning approaches, LMS, Kolb's experiential reflective learning session and stakeholder feedback for further enhancement.

ii. Provided facilities to prepare own learning materials using peer-discussion, blended learning approaches (e-learning materials, LMS), brainstorming sessions according to the first level of Bloom's taxonomy.

iii. Provided facilities to design own evaluation materials using the abovementioned methodologies for practice with their students according to the first step of Bloom's taxonomy.

Other activity models cover the remaining stages of Bloom's taxonomy and within each level of Bloom's taxonomy executed at all the stages of Kolb's Excremental Learning in addition to the other blended learning technologies. This proposed model is expected to achieve both surface and the deep learning outcomes based on the mixture of traditional pedagogical techniques with modern e-learning techniques in a collaborative and active learning platform.

8. Methodology for the validation of the model through statistical investigation

Students' knowledge about programming and problem solving were tested at six activity levels, which is the application model previously discussed. They were activity levels 2, 3, 4, 5 and 6 against the initial level (activity level 1: face-to-face traditional approach). The evaluation of the activity levels with a common series of evaluation papers were used in three different schools and their feedback collected. For the outcome of the evaluation test at each level

of activity, paired t-test was used to determine the improvement among the levels of each activity (hereafter called treatments). In all, five hypotheses were used and each hypothesis was used to determine improvement between two consecutive activity (treatment) levels.

The following five hypotheses were tested and labeled as hypothesis 1–5:

Let μ_1, μ_2, μ_3, μ_4, μ_5 and μ_6 were population mean marks at face-to-face traditional approach (Activity Level 1) to Activity Level 6 (proposed different levels), respectively.

As the first hypothesis, Activity Level 1 and Activity Level 2 were used as follows:

H0: $\mu_1 = \mu_2$ (mean values of marks are same in both treatments).

H1: $\mu_1 < \mu_2$ (mean marks of treatment 1 < treatment 2).

Similarly, other four hypotheses were used for pair's treatment as follows: μ_2 versus μ_3, μ_3 versus μ_4, μ_4 versus μ_5 and finally, μ_5 versus μ_6, and hypothesis were labeled as hypothesis 2, hypothesis 3, hypothesis 4 and hypothesis 5, respectively.

The outcome of the paired t-test of each hypothesis was obtained. It was decided that the acceptance of hypotheses or rejected, based on the 5% significant level P value ($p < 0.05$, then the null-hypothesis can be accepted).

Further, to investigate any variations in the outcomes of the experimental model school wise (analyze the difference between the groups), the analysis of variance (ANOVA) statistical model was used.

8.1. ANOVA test for comparison of performance school wise

To test the difference between the schools' performance in connection with the outcome of the implemented application model, the hypothesis 6 was used.

Hypothesis 6:

H0: students' performance in School A, School B and School C is the same (i.e., H0: μ School A = μ School B = μ School C).

H1: students' performances are different in at least one school from others (H1: At least one mean mark is different from the others).

Based on the P value of ANOVA table, one can decide whether H0 can be rejected. If 95% confidence interval level p value is greater than α (0.05), therefore, H0 cannot be rejected.

9. Implementation of the experiential application model under the test platform

According to the methodology described earlier, the implementation of the proposed model was carried out and few samples of the implementation are represented in **Figure 3**.

Figure 3. (Left) Implementation of application model to the introductory session. (Right) Introduction to Bloom's taxonomy and how to apply Bloom's taxonomy to the teaching and learning.

The session output shows that the teachers were motivated to learn Bloom's taxonomy and motivated teachers used Bloom's taxonomy in their teaching and learning paradigm of ICT, which was embedded in the proposed application model. During and after the series of Stage 1 of the study, the success of the session was observed and analyzed using the facial behavior of teachers using the Seven Universal Facial Expressions of Emotional Methodology.

According to the analysis outcome of the seven universal facial expressions of emotional methodology, on average, 74% of teachers happily did the activities included in the application model. This result shows a 24% of increase with respect to the initial situation (before implementing the application model).

9.1. Implementation of the proposed model in respective schools

Activities, implementation procedure and results of the trained teacher-student and peer-to-peer student model (the Sub Module 3 and the Sub Module 4) are as follows:

The activities used in Sub Module 1 and Sub Module 2 were applied to the implementation of Sub Module 3 and Sub Module 4 using the role model approach. Initially, teachers conducted the face-to-face session using course materials provided at the training of trainers' implementation sessions as in the role model approach. Some trainers (teachers) had also prepared daily course materials and activity sessions based on the experience obtained from the series of workshop sessions in Sub Module 1 and 2. Further, trainers provided facilities to conduct peer student group discussions as they learned from the series of workshops. Samples related to the implementation of the proposed model in schools using the role model are shown in **Figure 4**.

In implementing Sub Module 3 and Sub Module 4 in the respective schools, trainers used blended learning approaches learned from Sub Modules 1 and 2. Teachers applied the application model activities learnt from Sub Module 3 and Sub Module 4 in a reflective and enhanced manner. On some occasions, the researcher gave feedback through classroom observation sessions. The evidence can be seen in **Figure 4**.

The application models were implemented and tested fulfilling the specified requirements in selected schools using the role model approach and using the design approach shown in model. Teachers were able to fine-tune the application model with their students with the help of the

Figure 4. Sample event at the implementation of the proposed model in respective schools.

researcher. At the beginning, students also used face-to-face activities toward their learning process. After a series of lessons, they were motivated to use blended approaches to enhance the learning process. Based on the feedback of students, teachers and the ICT instructor, the researcher was able to judge the success of the application model through the facial behavior of the students and outcome of the inferential statistics analysis.

10. Outcomes of the study

The following section shows the results in implementing the proposed experimental application model in selected schools. Based on the statistical analysis techniques, as shown in the following sections, it proved the validity of the experimental model and its suitability for a developing country like Sri Lanka.

10.1. Evaluation of the proposed application model

The final evaluation of the proposed application model is based on the outcome of students' activities carried out by the trained teachers in three different schools with the help of the researcher.

A sample of 26 students from School A, 16 students from School B and 19 students from School C were selected based on availability. Students' knowledge about programming and problem solving were tested at six levels. They were face-to-face, Activity Level 1, Activity Level 2, Activity Level 3, Activity Level 4, Activity Level 5 and Activity Level 6. The mean mark of each block at each treatment level was calculated and is given in **Table 4**.

Treatment	Block		
	School A	School B	School B
(1) Activity Level 1 (face-to-face)	40.50	47.25	42.00
(2) Activity Level 2	42.20	49.25	43.67
(3) Activity Level 3	46.21	51.80	47.74
(4) Activity Level 4	50.35	56.06	54.72
(5) Activity Level 5	55.20	59.60	58.39
(6) Activity Level 6	60.00	67.31	63.00
	N1 = 26	N2 = 16	N3 = 19

Table 4. Mean marks of each block at each treatment.

Further, during the implementation, test cases were performed. In all test cases, common evaluation activities were given. These activities were prepared at the implementation of the application model stage with teachers. **Table 4** shows the students' mean marks for different treatments.

According to the abovementioned results, it was concluded that there is a gradual increase in students' performance when proper implementation of the application model is carried out. For each treatment, paired t-test was used and the following outcomes were obtained. As input to the paired t-test, mean data given in **Table 4** was used. Further, paired t-test was used to test the improvement between the levels of each treatment.

Similarly, **Table 4** shows that $\mu 2 < \mu 3$, $\mu 3 < \mu 4$, $\mu 4 < \mu 5$ and $\mu 5 < \mu 6$. In other words, students' performance has increased in an incremental manner.

In addition to the outcome of the hypothesis testing, **Figure 5** shows the performance of students with different activities.

Figure 5 shows students' performance increasing at each activity level. Further, all the schools show a pattern of increase in performance behavior.

The inferential outcomes and the graphical representation from implementing the proposed application model helped to conclude that the activities contained in the activity series contributed toward increased student performances.
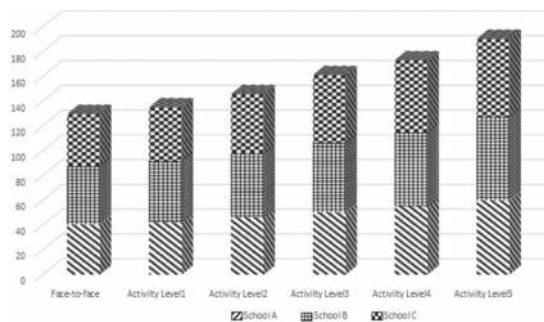

Figure 5. Stack chart to represents students' performance in different activities in three schools.

To investigate school wise variations (analyze the difference between the groups) in the above conclusion, the following analysis of variance (ANOVA) statistical model was used.

10.2. ANOVA test for comparison of performance school-wise

To test the difference between school wise performance in connection with the outcome of the implemented application model, the following hypothesis was used.

Hypothesis:

H0: students' performance in School A, School B and School C are the same (or HO: μ School A = μ school B = μ School are same).

H1: Students' performances are different at least in one school from among others (or H1: At least one mean is different from the others).

P value of ANOVA is 0.416. So that 95% confidence interval level p value is greater than α (0.05). Therefore, H0 cannot be rejected. It is not evident that performances are different by school wise. Ninety-five percent confidence interval for mean marks also confirms the same (confidence intervals are overlap). According to the outcome of the abovementioned statistical model, it was concluded that students' performance increase remains the same in all three schools (**Table 5**).

The application model confirmed its validity through the explored statistical models. It is interesting to note that the general view of the teachers who participated in the testing of the application model in schools was that the model looks feasible toward enhancing the quality of ICT education in Sri Lanka and, with proper investigation it can also be extended to other developing countries.

Source	DF	SS	MS	F	P
School	2	114.2	57.1	0.93	0.416
Error	15	920.2	61.3		
Total	17	1034.3			

S = 7.832 R-Sq = 11.04% R-Sq(adj) = 0.00%

Individual 95% CIs For Mean Based on Pooled StDev

Level	N	Mean	StDev	– + –	– + –	– + –	– + – ---
AnulaVidyalaya	6	49.077	7.583	(–-----------*-------------)			
Samudra Devi Bal	6	51.587	8.435	(–-----------*-------------)			
Thursten College	6	55.212	7.442	(–-----------*-------------)			
– + –	– + –	– + –	– + –				
45.0	50.0	55.0	60.0				

Pooled StDev = 7.832

Table 5. One-way ANOVA: marks versus school.

11. Conclusion

The proposed experimental application model contains a mixture of traditional educational pedagogies and modern blended learning technologies to address the issue regarding enhancement of quality ICT education in Sri Lanka. The model has proved that Bloom's taxonomy levels provide more skills enhancement to teachers as well as to students in an effective manner if it is blended with e-learning technologies. Further, the model reduces the complexity of the TLA process and helps in achieving learning outcomes. Incorporating features like Kolb's Reflective Learning Circle and other techniques such as activity-based learning and problem-based learning in different levels of Bloom's taxonomy has proved that more skills development of teachers and students can be achieved effectively compared to the existing methodologies. When the model was implemented, differences in performance levels of students in different schools were not noticed and this fact has been proved through the statistical analysis. It has also been proved that the proposed application model is suitable to enhance the quality of ICT education in Sri Lankan schools. Therefore, it can be concluded that the application model using a researchable framework could help improve the quality of ICT education and enhance the teaching, learning and assessment (TLA) process in Sri Lankan schools effectively. Hence, it is recommended that the proposed experimental model can be used first to train the teacher-trainers island-wide. However, once trained, teacher-trainers need to actively practice and sustain with their students what was newly learned. To conclude, the usage of the proposed framework would, undoubtedly, help to improve the existing methodologies along with pedagogical techniques and e-learning approaches in ICT education of Sri Lankan schools as well as in other developing countries. Adhering to the process, probably, would help to overcome global ICT challenges in the schools' environment.

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