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A Feasibility Study of an Interactive Shared Single Display Groupware in Resource Constrained Schools

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One pressing issue in resource constrained schools is the lack of access to computer facilities for learning. A single display groupware (SDG) is explored in this paper to provide an alternative solution for this limitation where it allows multiple users to work concurrently on a single computer display. This study aims to investigate the feasibility of SDG as an educational approach in resource constrained schools. The prototype SDG system RimbaIlmu, is designed and developed. Quantitative evaluations are carried out where the results indicate its feasibility in students' engagement and learning performance, while overcoming technical constraints. Limitation of the SDG is also presented with the intent of guiding future improvements.

Keywords: Shared single display, collaborative learning, groupware, evaluation, education technology

INTRODUCTION

Computer aided learning (CAL) systems are commonly used to augment the learning process by encouraging a learner-centric approach. The hope is the learner will be able to transition from traditional rote learning to intelligent learning. CAL can also be seen as a possible alternative to traditional learning where an effective pedagogical platform is provided through experience learning, reflection and action to develop different cognitive skills such as understanding, application and analysis. Apart from that, it also promotes interactions between the learner and tutor/instructor, as well as enables interactions between users and resources through multi-sensory human-computer interactions (Perrraton et al., 2000).

CAL's strengths includes supports for students' engagement, interaction, individuality and collaboration in teaching and learning to encourage active learning. In Malaysia, CAL systems have been introduced to motivate students to learn (Abodollah et al., 2010), promote interaction and collaboration in teaching and learning (Saad et al., 2007), enhance students' engagement and to further improve the effectiveness of teaching and learning in

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classrooms. To date, two common CAL systems have been developed and adopted in Malaysia. They are the (i) multimedia courseware and (ii) game-based learning (GBL). The former presents course content in various media forms such as audio, video, animation, graphics, text, voiceovers and narrations (MZ et al., 2008). GBL on the other hand creates a profound impact for specific learning goals and experiences, via a games paradigm with underpinning pedagogies. The main objective is to deliver content in a more interactive and creative manner (MZ et al., 2008).

Recently, mobile games have permeated elementary academics as instructional media to complement teaching and learning (Cheah et al., 2013). To further enrich the learning experience, 3D-virtual simulation environments have emerged, providing a social space populated with virtual presence of other learners. This creates an immersive and real life experience, which also constructs a shared platform where students can discuss, learn, synchronously and asynchronously re-learn, all unbounded by distance (Safaei & Shafieiyoun, 2013; Normala et al., 2013; Mohd-Hishamuddin et al., 2013).

As mentioned, CAL systems in schools have been embraced as an educational tool to enhance teaching and learning as well as to reinforce concepts. To further encourage and validate its adoption, feasibility studies on deploying CALs and its learning effect as a complementary tool seems necessary. This is especially relevant for teaching and learning in indigenous communities within rural areas. It is imperative to highlight the challenges faced in introducing education technology to the rural communities. Unlike their urban counterparts, the populace in rural areas has minimum or no exposure to technology, creating a huge digital gap. Cultural background is another hurdle where it affects behavior and acceptance towards ICT and other forms of technology. Limited access to computer facilities in rural areas also discourages the adoption of CAL.

In this paper, we explore the use of a single display groupware (SDG). A single display is seen as practical, as it minimizes the setup requirement for computing hardware and software, which is as mentioned, lacking in rural areas. The SDG allows collaboration and cooperation among students. Tasks are performed on a multi-user single computer connected to a single display. Several shared SDG projects have been introduced in remote areas (Moraveji et. al., 2008). However, to this day, no empirical study has been conducted on the potential of this technology as a CAL system within rural communities in Malaysia. Within this context, this study will attempt to present the exploration results of the SDG system RimbaIlmu, where its impact on learning within the communities are scrutinized.

This paper presents the development and evaluation of the SDG system RimbaIlmu, in resource constrained schools in state of Sarawak, Malaysia. RimbaIlmu is designed as an after-school program to allow the students to learn *Bahasa Malaysia* as leisure-time activity. *Bahasa Malaysia* is the country's national language, which is a compulsory subject in the school curriculum that also acts as the medium of instructions in the education system. RimbaIlmu supports up to a maximum of four players on a shared single display running on a single desktop. It also provides independent input channels for all individual players through the use of mice to complete the activities.

The following section presents a detailed description of RimbaIlmu, followed by the design principle used, the overall design and the interaction design. The visual presentation of RimbaIlmu is available next. A preliminary evaluation is conducted in two education technology related workshops. The results of RimbaIlmu's feasibility study in schools are then presented and followed by concluding remarks regarding future works.

DESIGNING RIMBAILMU

RimbaIlmu is designed as a shared single educational groupware involving collaborative and independent learning without a teacher's/instructor's supervision (Cheah

et al, 2014; Cheah et al, 2015a; Cheah et al, 2015b). It enables simultaneous use of multiple input devices to provide active control for every player and allows for content update of the latest activities by populating it with new questions from time to time.

The design principle is based on the Computer-supported collaborative learning (CSCL) design with a certain degree of flexibility as a form of peer learning through social interaction. Internally, RimbaIlmu is equipped with a simple core management service, which is briefly described as follows:

1. *Coordination* presides over tasks management and concurrently manages multiple users. This service predetermines the order of tasks and provides the decision of order as to who performs specific tasks and which roles in the activities;
2. *Game flow* - Once a game commences, all the players will have to complete the given tasks where players are not allowed to exit or pre-maturely quit from the game; and
3. *Interactivity* – This service handles multiple participants' responses synchronously. Rules are designed to provide equal privileges to every participant to ensure a fair distribution of chances.

Figure 2 presents a screenshot of the interface. In general, the students' workspace is divided into separate regions on the same screen. A dashboard of the players' status is displayed showing the gameplay and points obtained, status of the player's turn, the timer, and the access to the control buttons. In the example shown in Figure 2, four players are assigned their own regions. Each player's profile is represented by an avatar (different animals), which is highlighted in red boxes. Every player is given autonomous control of their own mouse but with restricted movement. Player 1 to 3 assumes the student's role and can only move within their own regions. Player 4 on the other hand acts as the assessor, who is able to move across all regions to check the answers. The composition of the interface layout is designed with basic principles in mind to eliminate visual clutter and occlusion as well as to provide consistency of the look and feel.

Figure 2: Screenshot for the intermediary interaction style in RimbaIlmu

A PRELIMINARY EVALUATION OF RIMBAILMU

EVALUATION FROM WORKSHOPS

RimbaIlmu was evaluated in two education technology workshops between May and October 2013. The 1st Colloquium of Learning Science, which is a regular symposium for the Master of Learning Science program, was the first venue to demonstrate RimbaIlmu. The audience consisted of postgraduate students of the program where most were teachers by profession. In all, 15 people participated in the study. In September 2013, we conducted a workshop to test RimbaIlmu among teachers and teachers' trainers at the International Conference on Teaching and Learning Through Games (ICoTLG), held in Kuching,

Sarawak. This conference gathered teaching experts from training institutions, schools as well as Non-governmental Organizations (NGO). Altogether, 20 participants attended the workshop.

In both workshops, the participants were given the opportunity to evaluate the system where feedback was given through questionnaires (feedback forms). Two main themes in the questionnaires are related to usability and intuitiveness, and satisfaction of using RimbaIlmu.

From the responses of 31 participants, we discovered that a majority agreed that RimbaIlmu was user friendly, where 13% strongly agreed on it. A small minority had a different experience where 6% of the participants did not agree to this attribute due to the lack of clear instructions and the absence of a help section. Meanwhile, most of the teaching professionals agreed on the feasibility of RimbaIlmu as an education tool in schools particularly in a resource constrained environment. 97% of the participants agreed that the students in rural schools will be able to accept this technology. Participants also provided suggestions relating to the deployment and also potential improvements for the system. Notable suggestions include:

1. RimbaIlmu is an interesting application and should be deployed in rural schools;
2. It would be great if RimbaIlmu covers Science and Mathematics;
3. RimbaIlmu can be used for problem based learning;
4. We need to limit the number of mice in order to reduce confusion during activities involving mouse movement; and
5. The instructions of RimbaIlmu must be clearer and more consistent.

Based on these feedbacks, we improved the RimbaIlmu and deploy RimbaIlmu in local schools in Sarawak, Malaysia namely St. Michael Entingan school and SK Bario. Video recordings were carried out during field testing to capture the students' interactions while attempting the RimbaIlmu activities. We first present the usability study of RimbaIlmu in this section. The details of the experiment setting in the two schools are described in the next section.

EVALUATION FROM SCHOOLS

The two schools selected are from different districts. The first school (St Michael) is located in the semi urban area of Kota Samarahan, Sarawak. It is a small primary school which consists of less than 200 students. The school had just completed building a computer lab, but without any computer facilities. The students involved in the testing know how to read, write and calculate. The second school (SRK Bario) is located in the rural district of Miri, Sarawak. The school has limited computer resources for teachers. Due to the geographical constraints and accessibility issues, we conducted and completed the tests in three sessions for both schools.

Participants and settings

In all, 30 students were selected from both schools comprising of 16 primary one students from St Michael's and 14 primary one students from SRK Bario. Students are grouped based on gender. The reason for such grouping is because gender separation has shown to have different impact on the results (Abnett et al., 2001).

Instruments

In this experiment, we firstly conducted a paper-based test. The test, which contains 20-questions, covers the primary one Bahasa Malaysia syllabus. The test includes two

sections namely "fill in the blanks" and "write a complete object". The questions require students to recognize and spell-out the objects. No time limits are imposed during the paper-based test to prevent students from getting tensed while attempting questions. After the pre-test, the students are exposed to the RimbaIlmu system. While all of this is going on, a video camera records students' interactions with RimbaIlmu. In addition, a screen capture software is also used to capture periodic still images involving students' interaction. Finally, we observe the students interaction and their behavior towards using RimbaIlmu. A post-test is conducted to evaluate student performance after using the system. We collect and analyze both pre-test and post-test results. A comparative analysis is then conducted.

Procedures

Table 1 *Agenda of the visit in testing the learning aspect of RimbaIlmu*

Trip 1	5 minutes briefing to headmaster 5 minutes ice breaking 15 minutes pre-test 20 minutes training on basic interaction in Rimbailmu *each group will turn taking on trying the system (dragging, keying-in, merging)- observe their interaction 50 minutes on playing with the system (3 computers have been allocated- 12 students together) 10 minutes on discussion with the students
Trip 2	Testing the system with different setup Group 1 Group 2 Group 3
Trip 3	Evaluate the use of RimbaIlmu in teaching and learning in after school program Post-test - 15 minutes Interview the students

The pre-test consisted of four sections with a total of 20 questions that covered the major learning points. We limited the number of questions to keep the test period short and to highlight the main topics. The test was conducted informally to allow the students to enjoy the experiment rather than treating it as another classroom test. Hence, the pre-test was conducted during the students' free time.

The questions were derived based on a *Bahasa Malaysia* (BM) reference book by Muhammad (2014). From the book publications, we had foreseen that there was confusion in producing the questions according to bands. Some book publications are based on level of BM literacy (e.g. Band 1, Band 2 and etc.) and there are different levels of competency corresponding to the bands for different reference books. Therefore, the questions deemed most appropriate for the band scale of 1 to 3 were used in designing the pre-test.

In the pre-test, section one consists of five questions in which the students are required to recognize the object with the corresponding term in BM. Section two consists of five questions in which the students need to spell the object correctly. Section three requires the students to complete the terminology of an object. In this section, students are required to understand the combination of words in forming an object. Finally, section four consists of questions for students to fill in the terminology. The students are required to read and complete the sentences in this test.

The students used RimbaIlmu in learning BM after the pre-test. With only 3 laptops and 12 mice available, the testing could only be conducted with 12 students where 4 students are assigned to a single laptop. Each test was carried out in each visit. The itinerary of the visit is shown in Table 1 with the experiment setup as detailed below.

For the St Michael students, we divided 11 students into 3 groups with one group comprising all boys (Group 1), while Group 2 was all girls (Group 2). Group 3 is gender-balanced with 2 boys and 2 girls. The group members were randomly selected, where all have a basic level of BM literacy (based on grades provided by their teachers). A similar group was setup for SRK Bario.

As previously mentioned, the students went through the RimbaIlmu after the pre-test. Post-test is conducted after the usage of RimbaIlmu. In the post-test, the same set of questions was given to the students. In this case, the students needed to answer 20 questions in four different sections. The post-test was conducted after the usage of RimbaIlmu. Prior to the usage of RimbaIlmu, students were required to attend the training session. The training period was 20 minutes where the question pool was extracted from the complete exercise. The training was meant to familiarize the students with the different interaction styles such as drag and drop, using a shared keyboard; clicking on the answers etc. Besides that, explanations were also given on how to use the mouse, touchpad, screen and computer. The students are then expected to explore the training version of RimbaIlmu. This training phase is important as some of the students are not exposed to computer technology. Hence, the training on the use of mouse and other computer components was necessary to prepare the students for the actual testing. Upon completion of the training, the students proceeded with the tutorial sessions where they completed a series of exercises in RimbaIlmu. The training consisted of exercises designed with the proposed interactive styles. Due to the limited resources, we randomly selected 12 students to use RimbaIlmu. The others students will then take turn in using the system during training.

Pre-test and Post-test results

Table 2 *Pre-test/Post test results, St Michael Entingan*

No.	Name	Group	Pretest	Post test
1	student	Girl	14	14
2	student	Girl	15	16
3	student	Girl	16	12
4	student	Girl	19	19
1	student	Boy	17	15
2	student	Boy	15	17
3	student	Boy	15	18
4	student	Boy	20	17
1	student	Mix	16	10
2	student	Mix	20	16
3	student	Mix	20	18

Table 2 shows the number of scores for the pre-test and post-test among the students from St Michael. The highest score for the pre-test was 20/20, whereas the lowest was 14/20. Three students managed to score full marks during the pre-test. By having 40% as the passing score, all the students were able to pass the test. The same standard was also used for the post-test. The post-test results were captured after the usage of RimbaIlmu. The highest score for the post-test is 19/20 and the lowest score was 10/20.

Table 3 *Pre-test/Post test results, SRK Bario*

No.	Name	Group	Pretest	Post test
1	student	Girl	15	17
2	student	Girl	18	18
3	student	Girl	16	14
4	student	Girl	20	19
1	student	Boy	17	12
2	student	Boy	15	12
3	student	Boy	5	4
4	student	Boy	4	6
1	student	Mix (G)	12	12
2	student	Mix (B)	6	2
3	student	Mix (B)	18	18
4	student	Mix (G)	17	18

Table 3 shows the number of scores for the pre-test and post-test among the students from SRK Bario. The highest score for the pre-test was 20/20 whereas the lowest mark was 4/20. One student managed to score full marks during the pre-test. By having 40% as the passing mark, 9 students were able to pass the test. The post-test results were captured after the usage of RimbaIlmu. The highest mark for the post-test was 19/20 whereas the lowest was 2/20.

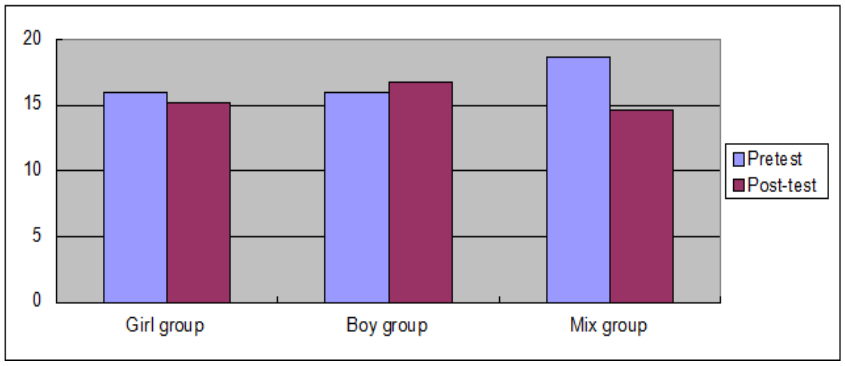

Figure 6: Pre-test and post-test across different setting in St Michael Entingan

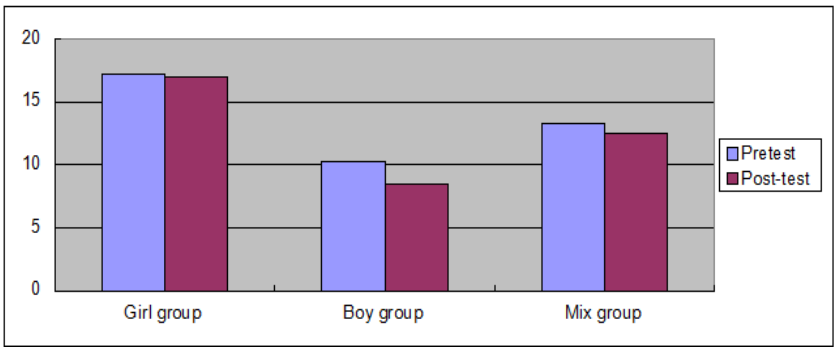

Figure 7: Pre-test and post-test for SK Bario in average

Work had been done to understand the effect of gender differences in shared single display environments (Abnett et. al., 2001). We followed the same practice and grouped the students based on gender, with one group being mixed. The results are shown in Figure 6 and 7. It was interesting to see that the performances of the groups in both schools were

almost equal. The girl groups seemed to always achieve better results. This was followed by the boy groups followed by the mixed groups.

From the overall analysis, it was interesting to see that the results of the pre-test and the post-test results among the boy groups has slightly reduced. On the other hand, the test results for the girl group was maintained for SRK Bario, but declined for the girl students in St Michael. This trend also occurred for the mixed groups (in both schools?). Although there were reduction in the post-test, but the reduction was not significant. In all, there was not much difference in learning setup based on gender. The students still maintained their performance prior and after learning together in different gender setting.

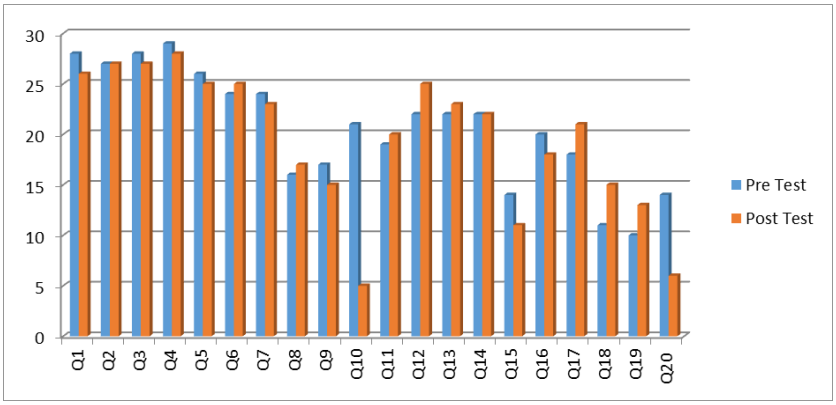

Figure 8: The pre-test and post-test results for the students according to questions

As previously mentioned, both tests consist of 4 sections. There were 5 questions in each section. Figure 8 shows the difference between pre-test and post-test for both schools. As we can see the scores were the highest for both the pre-test and post-test in section one. For section two, only Q6 and Q8 had a higher score for the post-test. The score was quite low for Q10 post-test. In section four, Q20 also had a rather low score as compared to the rest of the questions in this section. From Figure 8, the students had difficulty to answer questions in section two. For section three and four, the scores were also not high as compared to section one. However, the post-test for section three and four were much higher than the pre-test. Even though section one gave quite high scores for both pre and post-tests, pre-test scores were much higher in this section. Perhaps the students are influenced by the incorrect answers from the students during the RimbaIlmu activities.

RimbaIlmu for Knowledge Retention

To evaluate knowledge retention, we used exercises that were considered difficult to answer by most of the students during the test. From the exercises, we identified the set of questions that students were not familiar with. They kept on asking for help and working on it for a longer period of time (522 seconds to finish 10 numbers of questions).

In the next try, the students went through those set of exercises. We adopted the interaction of merging in which the students were required to answer it correctly by working together with a shared keyboard, as shown in Figure 9. This exercise runs for a period of one hour. Upon completion, a post-test was conducted. Since all the answers were given by the instructor during the exercise, a zero score was given to all students.

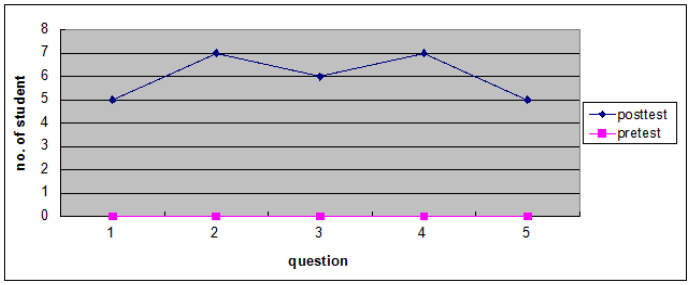

Figure 9: Knowledge retention in St Michael

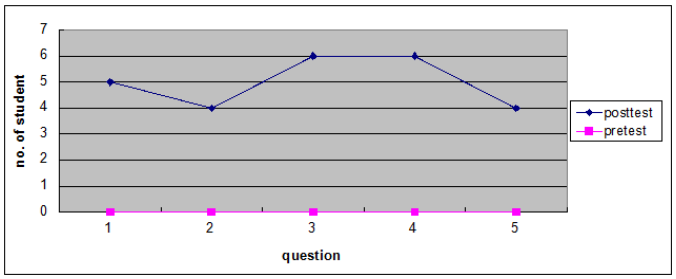

Figure 10: Knowledge retention in SRK Bario

Figure 10 shows the answer scores by a number of students. In order to reduce the bias during the analysis, we only collected the results from questions with similar level of difficulty. Out of 10 questions in the post-test, 5 were categorized as Band 2. Overall, RimbaIlmu can be deemed effective for knowledge retention among the students. The questions that were answered incorrectly during the play tend to be scored by some of the students.

In St. Michael, we tested RimbaIlmu with 12 students where 5 students managed to score correctly for question 1; 7 students scored correctly for question 2; 6 for question 3; 7 students for question 4 and 5 students scored correctly for question 5. On the other hand, 5 students scored correctly for question 1, 4 students for question 2; 6 students scored correctly for questions 3 and 4 and finally 4 students scored correctly for question 5. From the results, we can claim that RimbaIlmu was able to retain the learning among the students. Therefore, it can be deemed suitable as an after school learning tool based on the preliminary results that we obtained (shown in Figures 9 and 10).

So far, we have disclosed the benefits of a shared single display application to our community. In the following section, we will present the dark side of the collaborative learning using education tool.

THREAT VALIDITY

We conducted several analyses on RimbaIlmu. While the experiments were conducted, there were several threats in validating the results that were reported in this paper. During the usability study, not all participants were able to participate in the demonstration. This may have influenced their perception on the ease of use of RimbaIlmu. Besides, the teachers or trainer teachers had predicted that students' acceptance of the tool is based on their experience. This prediction was hard to quantify and was subjective. The analysis of the events that occurred during the play was based on manually identifying the event by the researchers. Due to poor video quality, it was difficult to justify the reasons behind the events. Hence, it was always based on the researchers' assumptions to include those events into the frequency of event. We conducted a series of tests to understand the experiment of

RimbaIlmu in schools. In general, the small population of students involved in the test cannot reflect the overall performance of RimbaIlmu for learning *Bahasa Malaysia*.

DISCUSSION

RimbaIlmu is an interactive education software, utilizing a shared single display. In this study, it has been evaluated among school teachers, teacher trainers, and students. To date, most of the reported results in this paper are similar to the works in testing the shared single display application in India (Moraveji et. al., 2008). Indeed, shared single display applications are usable in resource-constrained environments. The shared single display application is able to promote communication and interaction among the students. Also, the application is able to help in knowledge retention.

Most of the works like (Gupta et al., 2010; Moraveji et al., 2008; Alcoholado et al., 2012) have shown improvement based on post-test results after the usage of shared single display applications. Although the results from the pre- and post-tests did not show significant difference in our study, we open up a research question whether the interaction had influenced the students' performance especially in a shared single display environment. This led us to claim on the study the impact of interaction in the shared single display application.

Based on our experience, every single technology has positive and negative impacts. In this research, we presented the preliminary results of the negative impact of interaction towards student learning. From the findings, we argue that interaction should be supervised. When there is a mistake, the supervisor or instructor should correct the students immediately. We believe this issue should be addressed. If left alone, students that make mistakes risk perpetuating incorrect knowledge to their group members/peers. This can potentially lead to unwanted situations. We further argue that much work needs to be explored and reported on the other side of education technology in schools.

CONCLUSION AND FUTURE WORKS

Based on the obtained results, RimbaIlmu is able to engage with the community (e.g. Students, teachers) with positive affective impacts and motivational values. Meeting its core objective, RimbaIlmu is didactic, able to harness collaborative peer learning and interaction in a single shared display environment. However, improvements are still necessary. To further enhance effectiveness, emphasis should be placed on content enrichment in order to align with clear pedagogic objectives. According to (Prensky, 2001), effective educational game design can be achieved through the equilibrium of fun and educational values. Ideally, it can also include additional features such as in-game assessment and grading as a means to evaluate the transformation of the students' experience into knowledge. Apart from that, for better and deeper learning experience, the activities should be designed to stimulate and encourage learners to reflect, develop new ideas and opinions.

The evaluation was carried out on a specific set of learning games on adults on a modest scale. The hypotheses were drawn based on their experience as educators and after testing the system. However, it might be the case that the findings would be better if applied to a larger group of students, particularly from the rural areas with diverse cultural and academic backgrounds. Learning is a complex process, influenced by the learner's familiarity with the setting, their prior knowledge, their cognitive level and the cues for learning (Rennie et al., 1995; Rennie, 1996). The effort of future research in this area will undoubtedly provide more insights into learners' needs in the rural areas, enabling better adaptation of the system to their cognitive standards through exploitation of technology.

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