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INVESTIGATING THE IMPACT OF GAME-BASED LEARNING IN CHILDREN USING GSR

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***Abstract*—** This study aimed to investigate the impact of game-based learning on students' performance. For this reason, an empirical study was conducted which comprises the comparison of traditional learning and game-based learning. The participants were lower primary school students of age group 6-8 years. GSR NUL-217 logger sensor was used to record the physiological signals of each participant in real-time. An android-based game intervention named "KidsZoneApp" was developed which included Mathematics and English lesson plans according to the student's curriculum. The collected log data was used to calculate the changes in different dimensions of completing the task. ANOVA yielded a very significant difference between game-based learning and traditional learning groups. Overall, the results showed that game-based learning contributed to increased students' performance levels. Significantly, students under game-based learning completed the task in lesser time as compared to traditional learning.

***Keywords*— Mobile learning, Games, Early years education, Media in education, Applications in subject areas**

I. INTRODUCTION

The extensive use of new technologies such as the Internet, mobile phones, and social networks, has affected the learning process in schools and universities. Technology has a vital impact on education, making it possible to learn about new information systems easily. One of the most usual education systems, which are embraced by information technology, is game-based E-Learning (Huizenga, Admiraal, Dam & Voogt, 2019).

Games have become a significant piece of everybody's life and are viewed as the most well-known movement to discharge pressure. Kids bond with their friends and guardians by playing games. Added to this, games likewise controls the self-improvement of understudies, for example, memory games can look over mental aptitudes, word development games can improve relational abilities, and so on (Sharma & Kaur, 2020).

Gamification alludes to the utilization of game mechanics and game components in the non-gamified context (Sharma, Khosla, Khosla & Rao, 2018). Gamification as an instructive device is utilized to encourage learning, to support inspiration and commitment, to improve student's cooperation and exercise intelligence (Jagušt, Botički & So, 2018).

Mobile game-based learning shows the positive outcomes in students' learning performance. With the new technological developments, new methods for teaching through mobiles are arising. The use of mobile games in learning is a fruitful combination of active and suited learning with fun in a potentially excellent manner **(**Troussas, Krouska & Sgouropoulou, 2020).

Portable or area-based games give educators the chance of moving their teachings outside the study hall (Huizenga, Admiraal, Dam & Voogt, 2019). For example, students can rehearse classroom concepts while sitting at home. The game-based learning provides students another method of learning with so much fun and thus disposes of boredom.

Some researchers contend that gamification alone isn't adequate to bring the ideal learning results as their usage needs further investigation and observational evidence. Besides, it is additionally accepted that the one gamification component doesn't fit all the students; it may result in inverse to different students (Jagušt, Botički & So, 2018). The study represents the basics of sensing emotions by using the NUL-217 GSR sensor which records the physiological signals of each participant during the experiment.

The present work aimed to check the performance of students playing android-based game intervention "KidsZoneApp"; which is designed to provide as an interactive tool to compare the game-based learning and traditional learning. In addition to this, the time taken to complete both the modules would also be compared.

II. GALVANIC SKIN RESPONSE

Galvanic Skin Response (GSR), also known as Electro dermal Activity (EDA) and Skin Conductance (SC), is the proportion of the steady assortments in the electrical properties of the skin, for example, the conductance, brought about by the variety of the human body sweating ("Galvanic Skin Response (GSR)", 2020).

At the point when we are introduced to genuinely stacked pictures, recordings, events, or various kinds of enhancements whether it's certain or negative, our skin gives a lot of information on how we feel. At whatever point we are sincerely stimulated for example glad, pitiful, focused, anxious, dreadful, or shocked, the electrical conductivity of our skin changes. GSR is one of the most fragile measures for emotional arousal **(**Sharma & Kaur, 2020).

Our body contains millions of perspiration organs whose thickness fluctuates over the body. Sweat organs are being most elevated on cheeks and brow, fingers and palms, and just as on the underside of feet **(**Sharma & Kaur, 2020).

At whatever point the sweat glands are activated and get dynamic, they secret dampness through the skin pores. Variations of the positive and negative ions of the discharged liquid outcomes in the progression of electrical flow all the more promptly which brings about the computable changes in the skin conductance **(**Sharma & Kaur, 2020).

At the point when the skin conductance expands, skin obstruction diminishes. The passionate experience triggers the adjustment in the excitement level which at last expands the perspiration discharge and our pulse increments and our hands become sweat-soaked **(**Sharma & Kaur, 2020).

Fig. 1 NUL-217 Sensor **(**Sharma & Kaur, 2020)

Fig. 2- Placement of GSR Electrodes on Fingers **(**Sharma & Kaur, 2020)

III. METHOD

A. Participants

40 students were randomly selected to be the part of this experiment (age 6-8 years; 16 females and 24 males; mean age 7 years). The students were divided into two groups; Group A and Group B; based on whether they had a prior exposure of game-based learning or not. The students who have had a prior exposure of game-based learning were added to Group A (10 females; 10 males; mean age 7 years) and the rest of them were added to Group B (6 females; 14 males; mean age 7 years). Group A students were given game-based stimuli and Group B students were given traditional learning stimuli.

The students were recruited from different schools and consent was taken from their parents as well. All the participants had normal to corrected normal vision. None of the participant received any kind of medication during the experimental study.

Time limit was known to the students in which each level comprised of 3 minutes. Thus, the whole test strategy was of 18 minutes for every member. The information gathered in this exploration was utilized utilizing two information hotspots for both ongoing interaction learning and conventional learning (a) student-produced information (b) pre and post-test interviews.

B. Stimuli

To lead the trial, a custom versatile learning stage called "KidsZoneApp" was created which was straightforward yet media-rich to give better interaction to the understudies. Various Ids were produced which were given to every understudy playing game. This application was utilized to play out an examination on Group A understudies. The game plan included two levels – Maths and English. Every level appreciates three levels further for example low, medium, and high. This game stage was utilized to solve three main mathematics operations i.e. addition, subtraction, and multiplication. Additionally, the English portion contains scrambled words and vocabulary sections. For the experiment, each level was of 9 minutes which implies the all-out ongoing interaction was of 18 minutes.

The Group B students were given a print paper containing the same questions as that of the game. In both cases, time, correct and incorrect attempts of each student were being recorded on the backend.

C. Physiological Measurements

Neulog GSR Logger Sensor (NUL-217) was used to measure the physiological signals of each participant before, after and during intervention. The measurements were taken for both the groups at a sampling rate 20 samples/second. The electrodes were enclosed to the gel and connected to the non-preferred hand of each student. Before the application of electrodes, student's hands were sanitized with alcohol-based hand rub.

IV. PROCEDURE

All the procedures for game-based learning and customary learning happened in a soundproof room. The room temperature was kept between 20-40°C; since the GSR data can be disseminated at a temperature of more than 40°C and under 20°C. The members sat serenely on the seat and were advised to remain still so as to not move the wires of the anodes since it can make antiquities the sign. During the experimental phase, participants were accompanied by their caretakers in order to increase the comfort level. Children were asked not to glance around during the experimental phase.

Baseline arousal for each participant was recorded; for both types of learning; before and after the experimental phase. The baseline arousal was recorded at a sampling rate 20 samples/sec for the duration of 10 seconds. During this, each of the children was asked to close their eyes and sit comfortably.

In order to keep the track of room temperature DH11 sensor was used along with Arduino UNO in real-time. Before starting with the experimental procedure, the students were told about the significance of this empirical study.

A. Data quantification

The significant dependent variable is SCR. Since the SCR was recorded for real-time, it may contain noise, such as power line hindrance or vibrations from electronic devices. Therefore, the GSR signal was smoothed first with Low Pass Filter in MATLAB function to mitigate any present noise.

B. Traditional Learning Group

20 students of traditional learning group were taught manually before the experimental procedure. During the experiment, print papers containing same questions as that of game-based learning were used. Data for students in traditional learning was recorded manually along with the time was recorded for each student along with correct- incorrect attempts and total scores. Each students solved English levels first and then Math levels.

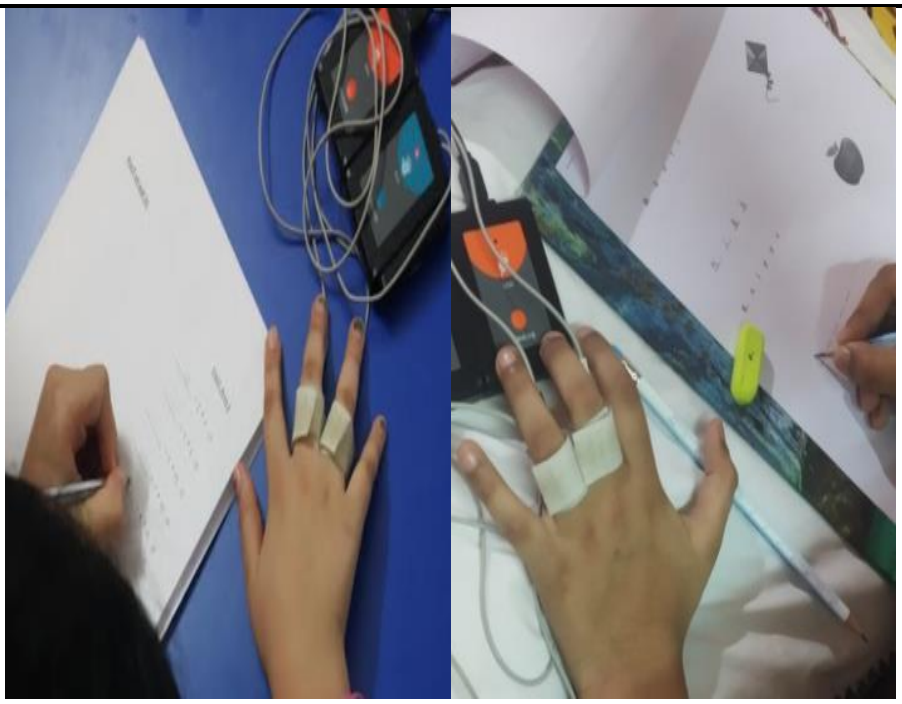

Fig. 3 Screenshots of Students Solving Questions in Traditional Way

C. Game-Based Learning Group

20 students of Group B were given video lectures about game learning. Students of this group have had a prior exposure of game-based learning from 1-2 years. Prior to the exploratory method, the understudies were instructed how to utilize the game and contact the screen. First author's mobile-phone was used for this process since that data was captured for the single student at a same time. The student's hands were sanitized before the application of GSR electrodes and after the removal of electrodes in order to make the hands sweat-free.

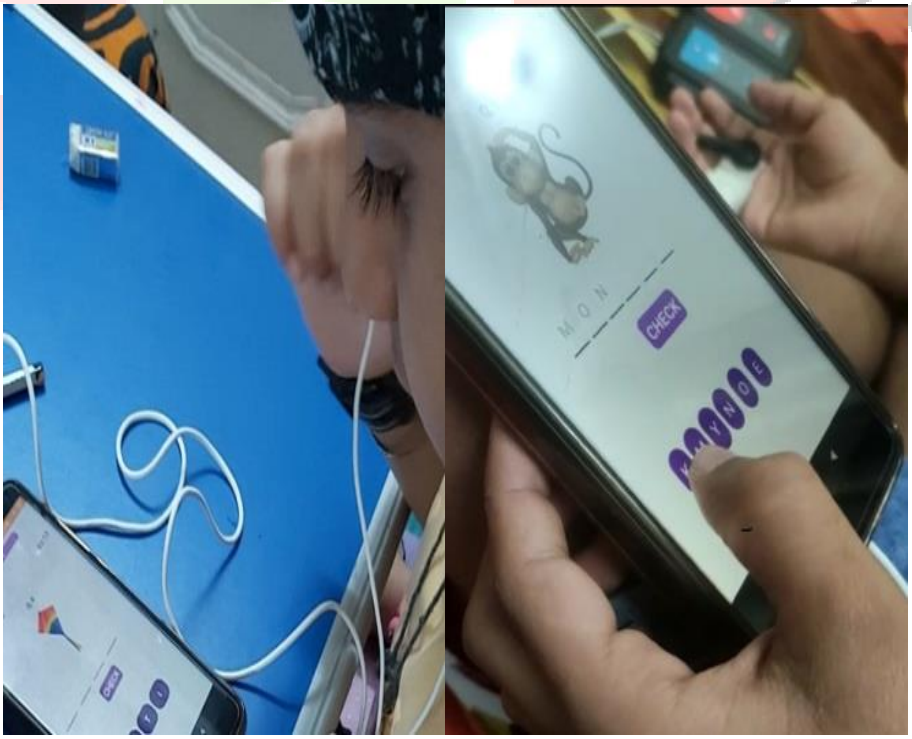

Fig. 4 Screenshots of Students Solving Questions under Game Based Learning

V. INTERVENTION PROCEDURE (KidsZoneApp)

As referenced before, mobile-based intervention "KidsZoneApp" was created which is a versatile mobile based stage to give better collaboration to understudies. The game plan contains two modules-English and Math. Every module further grasps three levels-low, medium, and high. Each level comprises of 5 inquiries. For each right answer, members were granted 10 focuses. No negative checking was there so as not to demoralize an understudy. Toward the finish of each level, the scoreboard was appeared for the individual competitor giving data about time, right, off base and all out scores.

While playing game-based learning, the time left for each level was shown at the right corner of the screen. AT the left corner of the screen, points earned by students are shown along with the number of questions the participant is solving. For every correct answer, a happy face pops up and for the wrong answer, a sad face pops up.

The English module comprises of scrambled words and vocabulary section in which students have to fill the blanks. The Math module consists of basics of arithmetic operations i.e. addition, subtraction, and multiplication. The options are given for every problem and students have to select the right answer. With each level, the difficulty level also increases. The questions are chosen based on the understudies' educational plan.

Fig. 5 Screenshots of KidsZoneApp

VI. DATA COLLECTION

Firebase Console was used to record the information about each participant having game-based learning. Since Ids were provided to Group A students, it was easy to track the student's performance by just looking at the logs. This database store information about time taken for each level, number of correct attempts, scores obtained, date and time of data entered.

There were two main sources of data collection: a) user-generated and b) pre and post-experimental interview. The interviews were conducted right before and after the experiment. Both the interviews lasted for 5 minutes each. In pre-experimental interview; which was same for both Group A and Group B; students were asked to answer variety of semi-structured questions (e.g. name, age, preferred hand, did they played learning game before, weather they prefer traditional leaning or game-based learning). In post-experimental interview of Group A students, they were told to answer the questions about their experience of using mobile (e.g. did they enjoy the game, were they stressed or nervous, did they guess any answer). In post-experimental interview of Group B students, they were nervous or stressed and did they guessed any answer. The elapsed time between the interviews and experiment procedure was of 5 minutes. Children were occupied with their caretakers in the interview as well so they can answer the questions without any hesitation.

VII. RESULTS

Hypothesis: It had been hypothesized that students' scores are more in game-based learning as opposed to traditional learning. Additionally, students are likely to complete the task in less time under game-based learning. Also, the students under game-based learning will show higher arousal than students of traditional learning.

Experimental Results: Figure 5 shows the mean score and time as an element of both learning gatherings (game-based and traditional). It has been seen from the table 1 that the two gatherings show a huge significance in mean points acquired by the understudies. AANOVA yielded a very significant difference in mean scores of game-based learning and traditional learning ($F(1, 38) = 8.168$, $p<0.05$). Similarly, ANOVA yielded a significant difference between the time yielded for both the learning ($F(1, 38) = 36.525$, $p< 0.001$).

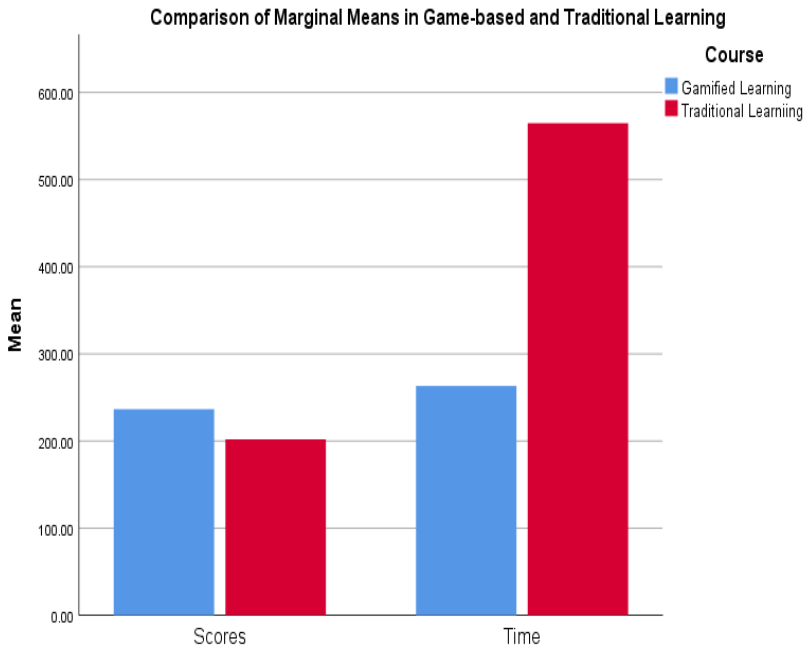

Figure 6- Overall Comparison of Game-based and Traditional Learning as a function of Score and Time

In figure 7 and 8, by comparing the mean scores and time of both the subjects as a function of groups (game-based and traditional), the ANOVA yielded a huge distinction in the two gatherings as factors of time and scores. The mean score of English module demonstrated huge difference ($F(1.38) = 1.780$, $p <=1.0$) and for Math ($F= (1, 38) =11.753$, $p=0.001$). Thus for time, ANOVA indicated noteworthy contrast ($F(1, 38) = 32.563$, $p < 0.001$) for English as well for Math ($F(1, 38) = 28.417$, $p < .001$). Figure and shows the mean scores and time taken by both the Groups A and B at the end of the task respectively.

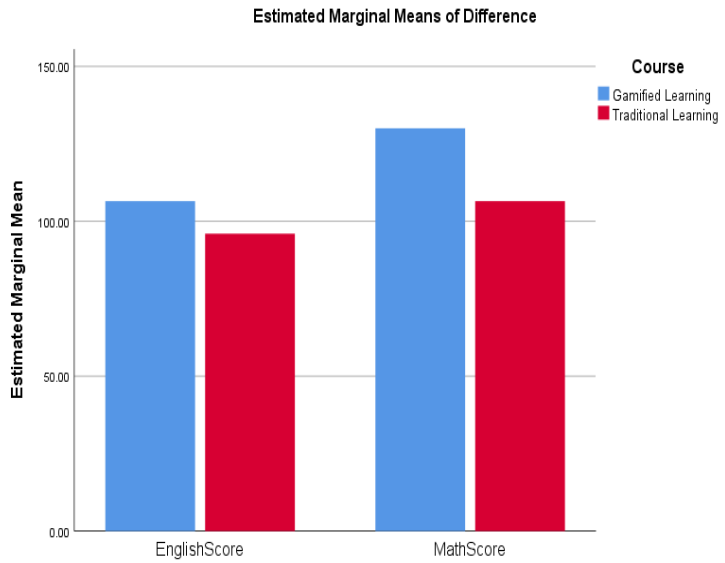

Fig. 7 Mean Scores of Both Subjects as a function of Game-based and Traditional Learning

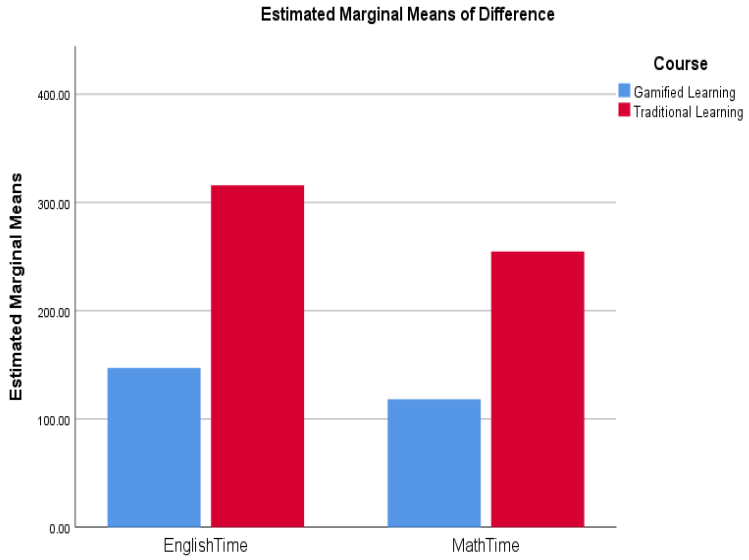

Fig. 8 Mean Scores of Both Subjects as a function of Game-based and Traditional Learning

Table no 1: ANOVA Results for Comparison of Game- based and Traditional Learning

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Scores	Between Groups	11902.500	1	11902.500	8.168	.007
	Within Groups	55375.000	38	1457.237		
	Total	67277.500	39			
Time	Between Groups	908419.60	1	908419.60	36.52	.000
	Within Groups	945105.50	38	24871.197		
	Total	1853525.1	39			

From the outcomes acquired, we can say that the two learning have a noteworthy distinction wherein game-based learning surpassed conventional learning. Likewise, there is a significant distinction between the average times taken by both the gatherings in the finish of the assignment which is leas In Group A as compared to Group B students. Moreover, in subject-wise comparison as well, game-based learning outshined traditional learning as a function of score and time.

The figure 9 shows the SCR reaction for pre and post-test standard for 12 understudies arbitrarily picked from both the gatherings. 6 understudies (A-F) were picked from Group A and 6 understudies (G-L) were picked from Group B. It had been plainly observed that the excitement of the considerable number of members expanded after a test convention. ANOVA yielded an exceptionally noteworthy

reaction in pre and post-experiment baseline (F (1, 22) = 3.29043, p<0.1).

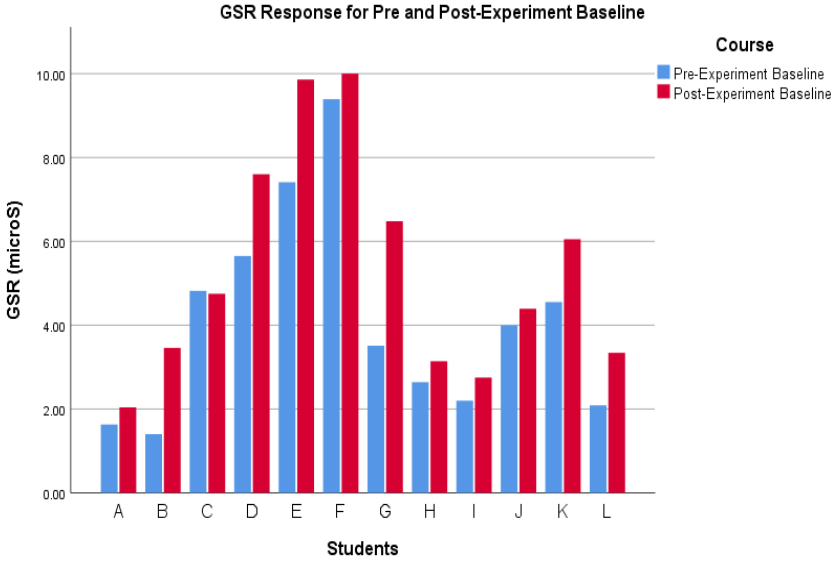

Fig. 9 Mean SCR as a function of Pre and Post-Experimental Baseline

The figure 10 shows the normal SCR reaction of understudies in both the learning (gamified and traditional). ANOVA yielded an exceptionally huge reaction in both the gatherings (F (1, 10) =3.919, p<0.1) indicating that there is a huge difference in SCR response of both the groups A and B under experimental procedure.

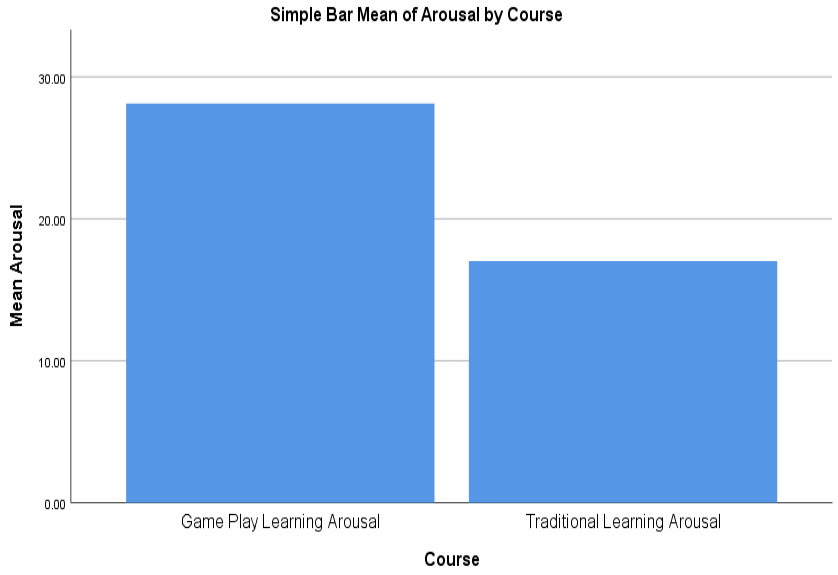

Fig. 10 Mean Skin Conductance Response as a function of Experimental Procedure

III. DISCUSSION AND CONCLUSION

The possibility of this examination was to investigate the adjustment in the presentation of game-based learning when contrasted with customary learning. For this reason, recently planned android based game intercession (KidsZoneApp) was created so as to give better commitment in understudy learning. The youngsters' showed improvement under game-based learning. It had been seen that understudies under game-based learning increased higher scores and furthermore they finished the undertaking in the least time. The youngsters under Group A uncovered higher normal imprints in the two subjects with lesser time. It had been seen in the outcomes that Group A had higher SCR amplitudes in pre and post-gauge and in the exploratory method too. It had additionally been seen that utilizing KidsZoneApp versatile based stage; kids can finish the assignment in a brief timeframe.

These outcomes support the fact that GSR relates to learning. Different examinations found associations among learning and expanded GSR. Understudies with higher GSR measures during learning scored best. The results of physiological signals are directly related to the outcomes of ANOVA applied to both the groups as a function of scores and time. Furthermore, the information level was related to higher GSR measures, with progressively splendid adolescents tending to be progressively responsive. Results also showed that the baseline of each participant from both groups A and B increased in post-baseline in comparison to previous baseline signal.

An android based game mediation with various subjects can improve the learning-abilities of understudies. In addition, this game can enable the understudies to rehearse their aptitudes out of the classroom lobby. Understudies can work on sitting at homes or anyplace around the bend of the world and can rehearse new aptitudes. The understudies were additionally given animated praise in the form of

'smiley' for every correct answer, which can motivate them to perform well.

In this research, it has been seen that a lot more is still has to be discovered in this field. Along with that, more sensors will be included in this research area in future work like ECG, blood pressure; in order to check the impact of any stimuli on the physiological signals.

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