Evaluating learners' emotional states by monitoring brain waves for comparing game-based learning approach to pen-and-paper

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***Abstract*—A new interest in the use of game factors while acquiring new knowledge has emerged, and a number of researchers are investigating the effectiveness of the game-based approach in education systems. Recent research in game-based learning suggests that this approach imparts learning by involving learners in the learning process. The game factors generate affective-cognitive reactions that absorb users in playing the game and positively influence the learning. This paper offers a comparison of the learning processes between the game-based learning and pen-and-paper approaches. In this paper the analysis of both learning approaches is realized through a brain-controlled technology, using the Emotiv EEG Tech headset, by analyzing the stress, excitement, relaxation, focus, interest, and engagement that the learner is experiencing while going through both approaches.**

***Index Terms*—game-based learning, emotional states, affective reactions, brain reader, electroencephalography, EEG.**

I. Introduction

Game-based learning (GBL) utilizes games as a mode for transferring learning. The core GBL phenomenon and process can be characterized by dimensions such as learning, game factors, affective-cognitive reactions and relations among them. Game factors generate the affective-cognitive reactions that absorb learners in playing the game. The integration of learning and game factors in game-based learning enhance the affective-cognitive reactions that positively influence learning [1]. Affective states (for example, flow, engagement, excitement, interest, etc.) normally tend to have a positive correlation with learning; whereas negative states (for example, stress, boredom, frustration, etc.) hold the opposite effect [2]. Most of the game-based learning theories lack empirical validation. Also, very limited research exists concerning the effect of emotional states produced by educational games on learning [3]. Mostly researchers have used questionnaires to collect subjective data on factors such as engagement and motivation that increase students adoption of learning games. However, the effect of these factors on learning are still dubious, leaving the model incomplete. Moreover, only subjective data might not always give reliable results [4].

Therefore, in this paper, we use the Emotive EEG Tech headset to compare the emotional states and learning outcome of a game-based learning approach with a pen-and-paper approach to obtain insights on how learning process acquire with reference to GBL phenomenon discussed above. In this research study, we proposed two hypotheses based on the concept that a GBL-approach (through integration of learning and game factors) enhances affective-cognitive reactions, inducing constructive impact on learning [1]; H1: The affective states (excitement, engagement, interest, and focus) experienced while acquiring knowledge through a game-based approach produces better results with respect to the pace of learning and learning outcomes compared to the pen-and-paper based learning approach, H2 : The game-based approach positively facilitates the learning process by enhancing affective states (excitement, engagement, interest and focus) as compared to the pen-and-paper approach.

An experiment is conducted in order to collect empirical data and to draw a conclusion. A specific learning scenario related to a sorting algorithm is provided to two different groups (one using a game-based learning approach and other using a pen-and-paper approach), which treated the same subject. A pre/post-test is used to measure learning outcomes. The results provide empirical insights into how learning process acquire while gaining the new knowledge through game-based learning, in terms of emotional states and learning outcomes, as opposed to a traditional pen-and-paper approach. The experimental findings evaluating six emotional states validates our hypotheses.

The rest of the paper is structured as following. Section II describes the related work. Experimental setup is presented in section III, while section IV presents the results and their analysis. Lastly, section V concludes the paper.

II. Related Work

A. Game-based learning approach

Game-based learning (GBL) is an educational paradigm that presents an innovative approach of utilizing games as a mode for transferring learning. Games are generally considered to have the potential to deeply engaging players by involving them in an activity. Therefore, a learning game is a game for educational purpose that imparts learning through active participation of learners in the learning process [1]. GBL phenomenon and process can be presented by three core dimensions: learning, game factors, and affective-cognitive reactions. Game factors generate the affective-cognitive reactions that absorb learner in playing the game. The integration of learning and game factors enhance these affective-cognitive reactions that positively influence learning [1]. Learner motivation and engagement are believed to be critical in improving the learning gains and game-based learning approach provides significant potential for increasing these affective reactions [2], [4]. Although the use of games as an educational tool has gathered significant attention but mostly mixed views are received from researchers and educators; who always acknowledge the need for students' engagement in the learning process but highlight the concern that educational games must provide this advantage of effects on engagement and entertainment without compromising the learning aspects [5]. Hence, for researchers the two main areas of interest are the extent to which educational games are engaging for the learners and if they actually impart learning [5]. It is essential to conduct assessment in the two areas in order to ensure the effectiveness of game-based learning approach. These two areas are the evaluation of participants' involvement in the game and evaluation of achieved learning outcome [6].

B. Evaluating the effect of emotional states in Game-based learning

Learning games tries to create intrinsic motivation by combining game experience and learning [3]. Affective states such as flow, engagement, motivation, curiosity etc. are normally considered to have a positive effect on any activity including learning; whereas negative states such as boredom, frustration etc. hold the opposite effect [2]. In spite of the fact that serious games are now one of the key types of entertainment computing, limited research is available regarding the effect of entertainment attributes of learning games on performance [3]. Although some research studies have highlighted that educational games can be attractive to learners as compared to traditional learning tools in certain environments. However, most of these studies have measured engagement only through questionnaires and surveys, limiting the current evidence to anecdotal [4], [5]. Sabourin and Lester [2] used a questionnaire to investigate how affective and negative states occur in the game-based learning environment called ''Crystal Island'' to teach microbiology and the findings showed that game-based learning can promote affective reactions and support learning simultaneously [2]. However, author highlighted the need to further explore how this emotion regulation controls or influences the learning process and suggested a controlled experiment comparing game-based approach with traditional learning as future direction to investigate this question. Giannakos, M. N [3] used a survey to evaluate the effect of attitudes on learners' performance in a math game for middle school children. The results showed that some attitudinal factors (such as engagement) had significant relation with knowledge gained by the game while others (such as intention to use and happiness) had no effect. Eseryel et al. [4] investigated the complex relationship between learners' engagement, motivation and complex problem-solving outcomes through massively multiplayer online game with middle school children using questionnaire and motivation inventory survey. Hamari et al. [7] used a survey to examine the impact of flow, immersion and engagement on learning in game-based learning settings using two learning games on physics and engineering dynamics with high school and undergraduate engineering students respectively. The results showed a positive effect of engagement on learning, whereas no significant effect between immersion and learning [7]. Hsieh et al. [8] used sequential analysis and observation to identify the lower and higher engagement patterns to characterize the learning processes of learners in game-based learning using a resource classification matching game with elementary school students. Rondon et al. [9] compared the game-based learning method with the traditional learning for teaching head and neck anatomy to undergraduate students by examining the learning gains and knowledge retention.

C. EEG to evaluate affective reactions/emotional states

Evaluating the emotional states (such as engagement, excitement etc.) of learners during any activity is often a difficult task. Several researchers have developed questionnaires to evaluate the player's experience in virtual environments. However, there are several issues in using these questionnaires such as context, wording and format. Therefore, there is an increasing need for a better approach to evaluate learners' emotions at an adequate level to get insights of the learning process and improve it accordingly [10].

Brain waves generate the electrical signals which can be meaningfully interpreted in accordance with the actions executed by the brain, by utilizing numerous computational devices and measures using electroencephalography (EEG) methodology [11]. Cernea, Daniel, et al based on their results, suggested EEG technology as a valuable alternative for measuring subjective parameters in different evaluation scenarios [12]. The wireless electroencephalographic (EEG) provides a method for recording and accessing the neural activity, allowing computer to analyze the information obtained from brainwave patterns produced by thoughts [13]. EEG systems provides different metrics for determining task engagement and arousal.

A number of researchers have explored different EEG processing algorithms for evaluation of cognitive workload and to measure the classification of positive and negative emotion [10]. Timothy McMahan et al. [10] aimed at validating the use of engagement, arousal, and valence index using Emotiv EEG headset. They intended to coordinate the task engagement data and arousal-valence data in order to establish a flow model. The results suggested that by combining engagement data with arousal data, thresholds can be established to indicate when a

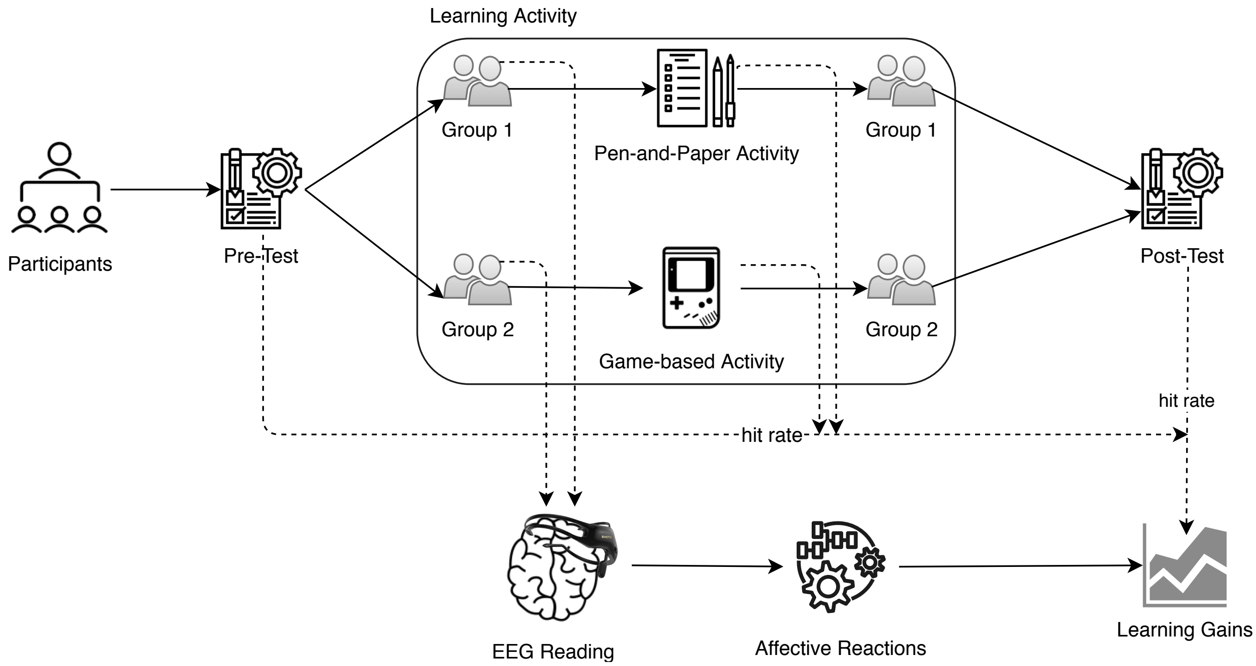

Fig. 1. Experimental setup of evaluating learners' emotional states by monitoring brain waves for comparing game-based learning approach to pen-and-paper

player exits a state of flow. Emotiv can be used for assessing the emotional and cognitive processing of players. Sourina and Liu [13] used EEG to measure the affective states of users watching a film. Andujar, Marvin, et al [5] investigated the level of engagement in learning from educational games compared to learning from a text document. Anderson et al. [14] compared different visualization techniques with regard to the level of burden they put on viewer's cognitive resources by passively recording the brain activity using electroencephalography (EEG) [14]. McCullagh et al. [15] used hybrid BCI methodology to collect EEG metrics during an immersive control task and the variations in EEG provide the objective measures for engagement of user with the task [15]. Desai, A. R. [11] used EEG method to conduct an experimental study for understanding and comparing coding in C and Python in terms of emotions and/or cognitive load [11].

III. Experimental Setup

This section provides an overview of our experimental evaluation of the learning process for pen-and-paper and the game-based learning approach using the brain wave reader technology, as depicted in Figure 1.

A. Electroencephalography

The brainwaves using the Electroencephalography (EEG) device are examined in this study for determining which affective reactions/emotional states contribute to the learning gain when subjected to pen-and-paper versus game-based learning approach. EEG is a recording of the electrical activity of the brain from the scalp. It measures voltage fluctuation within the neurons of the brain. An Emotiv Insight[1] device is used for the experiment. Emotiv Insight is a wireless 5 channel headset that gathers brainwaves to produce EEG signals. These EEG signals are then translated into data that can be analyzed to measure performances metrics. The headset features electrode sensors that is worn around the head, which picks up brainwaves. The headset contains 7 electrodes, of which 2 are reference electrodes. The remaining electrodes have locations on the scalp at AF3, AF4, T7, T8 and PZ points which are labeled according to the 10-20 system [16], as shown in Figure 2.

The EmotivPRO software is used along with the headset, which enables real-time display of six emotional states: Focus, Engagement, Interest, Excitement, Relaxation, and Stress levels. The real-time data is then recorded and stored on secure cloud storage for analysis.

B. Data Collection

The research focused on evaluating students' performance on an algorithmic problem for which the EEG data was collected from 22 computer science freshman. The students in their first year of studies haven't had any formal course on the algorithm subject as part of their degree yet. Out of 22 subjects in total, 7 were females and 14 males. The students were divided in two groups of 11 students each. One group to solve the problem on a paper in pen-and-paper based experiment while the other group to use a prototype game to solve the same problem in a game-based experiment. Both groups were provided with clear set of instructions concerning experiment part.

[1]Emotiv Insight, http://www.emotiv.com

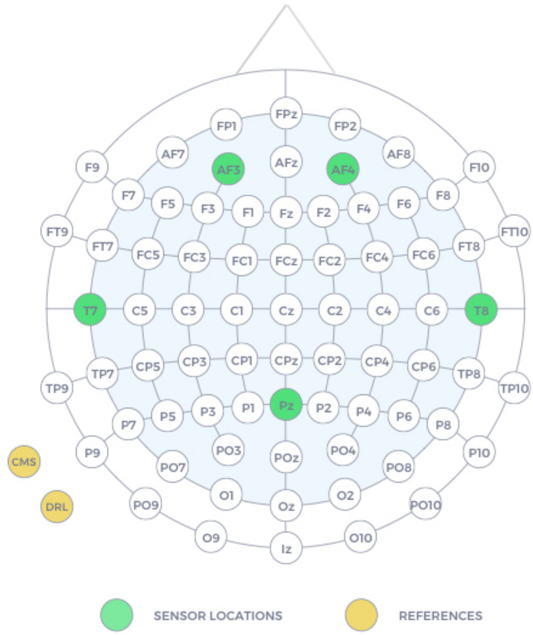

Fig. 2. Sensor location of EEG headset[1]

C. *Experiment Design*

As shown in Figure 1, the experiment consisted of three phases: (i) pre-test; to evaluate the background knowledge of the students (ii) problem solving exercise: solving an actual task, and (iii) post-test; to evaluate learning gain. An *Insertion Sort* problem was selected for the experiment.

The pre- and post-test consisted of ten questions each. For each question, three to four choices were provided, from which the students choose one. Both pre- and post-tests were the same, except for the order of appearance of the questions and the values for the array for sorting. The complexity of the problem and the array size for insertion sort was kept fixed. Additionally, the EEG data were collected for the problem solving exercise for both approaches.

D. *Insertion sort provided as game and through pen and paper*

The game-based learning group was provided with the insertion sort game. The game called *Sort Attack*[2] offered a short tutorial and a few examples at start to begin with, followed by the actual problem solving exercises. A screen shot from a game is shown in Figure 3. The game was offered as a prototype which lacked captivating features and game components [17].

The same scenario was provided for the pen-and-paper group, where a short explanation and a few examples were printed, and students were requested to solve the insertion sort tasks. During the learning activity as shown in Figure 1, the Emotiv insight headset was mounted onto the subjects for monitoring the affective reactions/emotional states. First 15 minutes of the data were collected from the subjects

[2]https://apkpure.com/ar/sort-attack/com.gamefulgrowth.sortattack.android

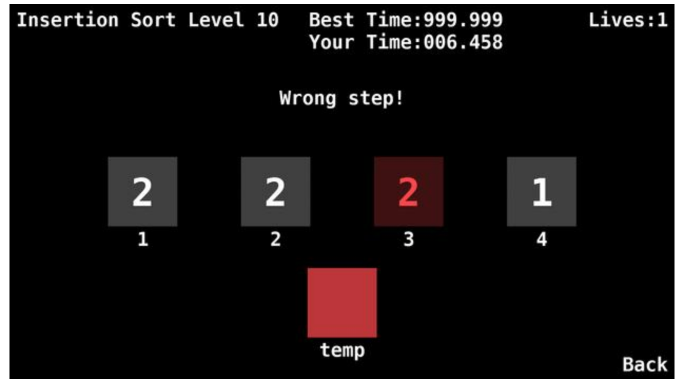

Fig. 3. Screen-shot from Insertion Sort game[2]

to measure and observe six emotional state variables, such as Focus, Engagement, Interest, Excitement, Relaxation, and Stress levels of each participant in real-time.

After this phase, the students were required to go through the post-test to evaluate the effectiveness of game-based learning versus pen-and-paper concerning learning gain.

IV. Results and Analysis

The subjects were asked explicitly about their knowledge of the topic on a 1 to 5 scale, where 1 was 'novice' and 5 was 'expert'. The self reported results were: 6% (1 student) as expert (5), 18% (4 students) as proficient (4), 14% (3 students) competent (3), 36% (8 students) advanced beginner (2), and 27% (6 students) novice (1). In other words, 77% of participants estimated low competences in algorithms which qualified them to participate in this study about students that do not have competences in algorithms.

TABLE I
THE QUESTIONS RELATED TO PRE-TEST

Pre-test questions	
Q1	What are the three algorithm constructs?
Q2	What does a searching algorithm do?
Q3	What does an insertion sort do?
Q4	What operation does the Insertion Sort use to move numbers from the unsorted section to the sorted section of the list?
Q5	What is the first change that insertion sort would make to this sequence to put it into ascending order: {4, 3, 2, 1}?
Q6	What is the first change that insertion sort would make to this sequence to put it into ascending order: {30, 24, 12, 82, 1}?
Q7	What are the correct intermediate steps of the following data set when it is being sorted with the Insertion sort?5,4,1,4, 3
Q8	Consider the following lists of partially sorted numbers. The double bars represent the sort marker (numbers before marker are sorted). How many comparisons and swaps are needed to sort the number after sort marker. [1 4 5 6 8 ||||2]
Q9	Consider an array of elements {9,8,3,2,1}, what are the steps of insertions done while doing insertion sort in the array.
Q10	Consider the array {6,4,8,1,3} apply the insertion sort to sort the array. Consider the cost associated with each sort is 10 dollars, what is the total cost of the insertion sort when element 1 reaches the first position of the array?

Figure 4, shows that hit rate (%) of pre- and post-test for game-based learners.

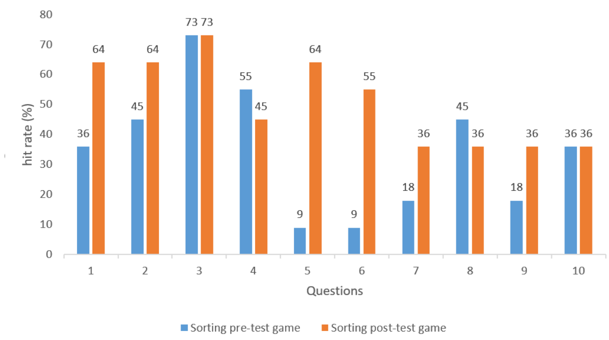

Fig. 4. Results of learning outcomes from game-based group

And Figure 5, shows that hit rate (%) of pre- and post-test for paper-and-pen based learners.

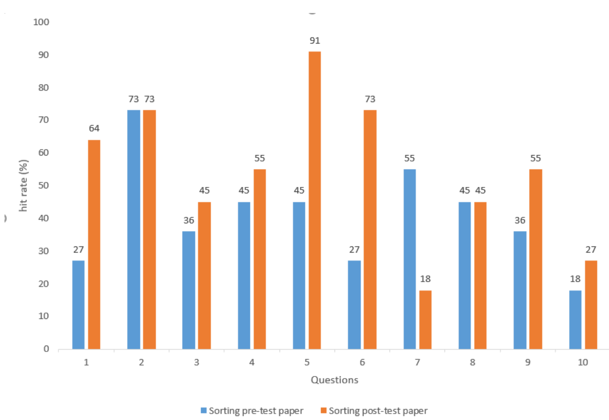

Fig. 5. Results of learning outcomes from pen-and-paper based group

From the result shown in Figure 4 and 5, the pen-and-paper group had overall better hit rate, inferring that learners from this group had prior knowledge of the topic.

However, to present the result of the learning outcome of both group of learners accurately, we calculated the learning gains by calculating the difference of pre- and post-test hit rates for each question in percentage for both groups, as shown in Figure 6.

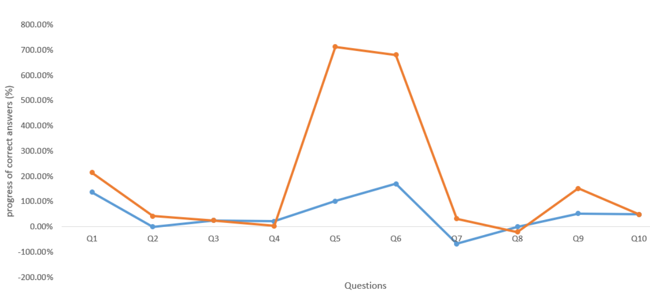

Fig. 6. Progress: game based versus paper based

Since the test was conceptualized on the theoretical and practical part, questions Q1, Q2, Q3, Q4, Q8, and Q10 represented the theoretical part, whereas Q5, Q6, Q7 and Q9 represented the practical part (Table I).

This division also reflected in the progression of learning outcomes for both group of students, wherein the major progression part was demonstrated in a practical part, as shown in Figure 6. Game-based learners experienced better progress in practical questions than pen-and-paper based learners.

The experimental findings of emotional states obtained from the EEG headset (Figure 7) showed that 15.38% of game-based learners were more stressed playing the sorting game and this might be because they reached more complex tasks to solve compared to pen-and-paper learners, game-based learners were also 10% more engaged and 8.77% more interested in the learning activity, 18.92% more focused and 27.27% of them experienced the learning activity more relaxed. Whereas 17.86% were less excited compared to pen-and-paper learners. The low excitement by game-based learners might be due to poor user experience design of the game, as stated in subsection III-D.

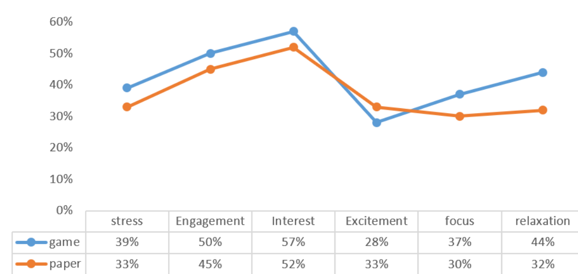

Fig. 7. Emotional states *(EEG data)*: game-based versus paper-based

Figure 8 shows the minimum and maximum value for game-based versus pen-and-paper based emotional states. In the game-based group, the stress attained the max value (44) in the tenth minute of the experiment. The engagement obtained its max value (56) in the eleventh minute, and excitement reached its max value (37) in the first minute of the experiment. The interest experienced its max value (60) in the third minute, while the focus (42) and the relaxation (50) achieved max value in the first minute of the experiment.

These findings show that the learners had highest focus, interest, and excitement in the very beginning of the game, and they experienced the max relaxation immediately after they started the game, but then the stress hit its max value when the complexity of the tasks within the game increased. A similar increase in the engagement was also observed after which the stress started to decrease. This is in line with the flow theory [18], according to which it is generally said that the flow emerges in the space between anxiety and boredom. The challenge of the game design is to keep the player in a flow state by increasing the skill level of the game while the skill level of the player increases in order to maximize the impact of them that results in learning. So, in this experiment as the challenge increases in game-based approach, the level of stress increases but the results show that the level of engagement also increases simultaneously which indicates that the level of learner skills was also increasing (means they were learning). Furthermore, the value of relaxation was also less towards the end, which means that the game-based learner skill level was not too high to fall in boredom and stress level after its max value at 10 min also again started decreasing towards the end which shows that challenge level was not too high for the learner to fall into anxiety. Therefore, from the analyses of complete data set we can conclude based on the values of stress and engagement that the game-based approach generates affective reaction (flow) that positively impact the learning which is in-line with our hypothesis.

The paper-and-pen based group experienced the max value (39) for stress in the first minute, max value (49) for engagement in the seventh minute, max value for interest (56) and excitement (48) in the first minute, max value (37) for focus in the sixth minute, and max value (39) for relaxation in the second minute.

Similar to game-based learners, pen-and-paper learners experienced interest and excitement at the very beginning of the learning activity. But then, in the middle of the learning activity, engagement and focus were overshadowed by stress. This experience occurred early in the learning activity, which is the opposite of the game-based learners experience, wherein the max value for stress occurred at the end of the learning activities. That said, immediately after reading the introduction of the learning activity, the learners experienced the max value of relaxation similar to the game-based learners. After analyses of the complete data set, we can conclude that engagement decreased towards the end in this group of learners.

Further, in the experiment, the game-based group experienced the min value (36) for stress in the second minute, min value (47) for engagement in the fourth minute, min value (53) for interest in the thirteen minute, min value (24) for excitement in the twelfth minute, min value (33) for focus in the third minute, and min value (38) for relaxation in the eleventh minute.

So the learners in the game-based group experienced less stress at the very beginning, which also indicated enhanced focus and engagement. However, in the end of the learning activity, they started to lose interest and excitement, and consequently, relaxation.

The paper-and-pen based group experienced its min value (30) for stress in the fourth minute, the min value (40) for engagement in the thirteenth minute, same as the interest (50), excitement (24) and focus (21), and the relaxation experienced its min value (27) in the fourth minute of experiment. Also, pen-and-paper group the excitement, interest, and focus hit its lowest value in the very beginning, but so did the relaxation. However, at the end of learning activity, the learners started to lose the engagement, while stress also disappeared.

We can observe from the above findings that the pen-and-paper learners were very interested and excited at the very beginning of the learning activity, similar to the game-based learners. The game-based learners were less stressed in the very beginning, but the stress started to increase in parallel to the complexity of the game. Whereas, the pen-and-paper learners experienced the opposite. They were very stressed in the beginning, and the stress reaches its min value after they became familiar with the exercises.

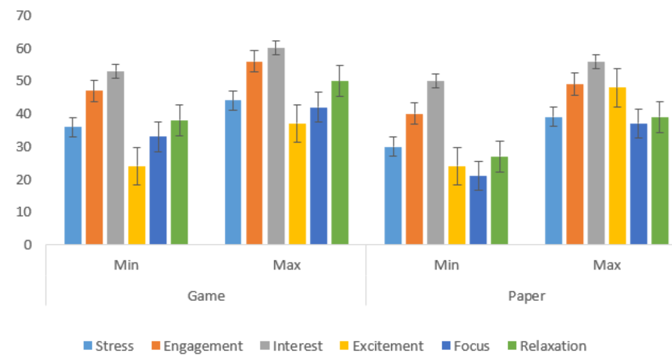

Fig. 8. Emotiv EEG data: Min and Max value of emotional states

Moreover, the game-based learners engagement was increased (as it hit the min value in the fourth minute and max value in the eleventh minute) with the complexity of the tasks, whereas the learners in the pen-and-paper experienced the opposite. They had better engagement in the beginning, but then it decreased during the end of the learning activity, which may have been reflected in cases when they wanted to stop the experiment because subjects raised questions related to more complex tasks.

Results in Table II shows how participants felt about six emotional state variables during the experiment.

TABLE II
USER EXPERIENCE COMPARED TO SIX EMOTIONAL STATE VARIABLES

Approaches	Emotional State	1	2	3	4	5
Pen-and-paper	interested	-	-	27%	55%	18%
	engaged	-	-	9%	45%	46%
	relaxed	-	9%	18%	36%	37%
	focused	-	18%	18%	27%	37%
	excited	-	-	36%	55%	9%
	stressed	18%	27%	18%	28%	9%
Game-based	interested	-	-	18%	9%	73%
	engaged	-	-	18%	45%	37%
	relaxed	-	-	28%	36%	36%
	focused	-	9%	-	36%	55%
	excited	-	18%	9%	45%	27%
	stressed	27%	27%	37%	-	9%

Along with post-test questionnaire, participants were also asked explicitly six additional questions regarding their experience to get subjective values of the six emotional state variables (interested, engaged, relaxed, focused, excited and stressed). For instance, one question explored the level of interest during this experiment, on a scale from 1 (not interested at all) to 5 (very much interested). And, from these data (Table II), we calculated the Pearson Correlation to analyze each of the variables between both groups to reveal relationships and correlations.

The Pearson Correlation results of post-test data between

TABLE III
PEARSON CORRELATION : GAME-BASED VERSUS PEN-AND PAPER DERIVED FROM POST-TEST DATA

Emotional state	Self-expessed
interested	-0.777
engaged	0.950
relaxed	0.999
focused	0.992
excited	0.411
stressed	0.630

the learners in game-based and pen-and-paper groups (Table III) shows that excitement, stress, engagement, relaxation and focus elements have a positive correlation, and the latter three aspects also have a significant correlation. Whereas, the interest variable has a negative correlations between the two approaches. This difference comes from the users that expressed their maximum interest (73% of them) using the game-based approach for learning activities (See Table III)

We also calculated the correlation between the EEG data of game-based versus pen-and-paper. The correlation values are computed for all six variables from fifteen minutes of recorded data, where the first and last minute recordings are emitted to avoid outliers. Table IV shows the recorded EEG data values for stress and engagement, where each row represents one minute of activity.

TABLE IV
GAME-BASED VERSUS PEN-AND-PAPER DERIVED FROM EEG DATA

Stress emotional state		Engagement emotional state	
pen-and-paper	game-based	pen-and-paper	game-based
34.44	43.55	46.77	48.66
38.55	36.44	46.44	53.88
33.44	36.77	44.77	47.55
29.77	35.77	44.11	47.33
30.22	37.66	45.22	49.77
31.33	37.77	41.33	50.33
30	38.44	49.22	50.11
33.66	38	47.55	52.33
33.11	43.22	44.11	46.88
33.11	44	42	50.88
36.33	42.55	39.55	56
33.44	37.55	42.44	47.44
30.55	39.66	45.22	51.22

The result of Pearson Correlation calculated from the EEG data (partially shown in Table IV) is shown in Table V.

TABLE V
PEARSON CORRELATION: GAME-BASED VERSUS PEN-AND-PAPER DERIVED FROM EEG DATA

Emotional state	EEG data
interested	0.327
engaged	-0.150
relaxed	0.344
focused	0.001
excited	0.395
stressed	0.213

The result in Table V show no correlation for the focus variable, whereas, for interest, relaxation, excitement, and stress, there is a positive correlation, although it is not significant. As for the engagement, the correlation is expressed negatively. This difference can be seen especially after the tenth minute where the group from the game-based learners were more engaged in the learning activity.

To conclude, besides the learning outcomes derived from pre- and post-test data and EEG data analysis, from the observation perspective, pen-and-paper group students required additional explanations from time to time, to move beyond doubts and concerns about the experimental scenario. In contrast, the game-based learners did not raise a single question during the experimental exercise, which is corroborated by the game factors (presented in earlier tables) about the affective-cognitive reactions that immerse learners in game playing [1].

Furthermore, the extra explanation required from pen-and-paper group members might have influenced the final result, which shows a minimal difference between both groups based on the EEG emotional state variables. However, besides the progress of the learning outcomes, the major difference between the game-based learners and the pen-and-paper learners was the average number of tasks that were solved during the fifteen minutes experimental phase. The game-based learners achieved approximately 20 tasks within that experimental time frame, whereas the pen-and-paper learners accomplished not more than seven tasks.

V. CONCLUSION

A study evaluating the impact of affective-cognitive reactions with the use of game-based learning approach on the learning gains is presented in this paper. In contrast to the traditional pen-and-paper learning activity, game-based learning positively facilitates the learning process through emotional states such as excitement, engagement, interest - among others. An activity is generated to test this hypotheses on two groups of first year undergraduates students in Computer Science Faculty. One group was given the task to solve a insertion sort algorithm problem on a pen-and-paper, while the other group had to solve the same task using game-based approach. EEG data of the participants were collected during the activity which monitored students' six emotional states.

As shown in the result, the game-based learners experienced higher progress then the pen-and-paper group (Figure 6) especially in the questions related to the practical part (Question 5, 6, 7 and 9). This difference was observed when comparing the learning gains between the game-based and pen-and-paper learners, even though extra attention and explanation was provided to pen-and-paper participants.

However, when analyzing the emotional state variables, there was no significant difference. One reason could be that the game lacked captivating design and engaging features, which could enhance affective-cognitive reactions. So further research would build upon these findings through usage of a more robust and engaging gaming platform.

This is an especially promising line of research because, when comparing the number of tasks solved by the participants of both groups, the game-based learners achieved more then the double number of tasks in the same time as the pen and paper group. In addition, most subjects from both groups - were excited to continue with the experiment.

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