Comparative Study on the Digital Game and Computer Simulation to Curtail Student's Misconception about Heat and Temperature

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Abstract

In this research article we explore the efficacy of a game-based learning approach to improve students understanding of the fundamental concepts of physics such as, heat and temperature. Heat and temperature are complex to learn by traditional learning methods. Students face complexities in learning such concepts of Physics. These complexities such as, mixing up the concept of heat and temperature and misinterpretation about the definition which results in misconceptions. A comparison was made between computer simulation-based learning (CSBL) and digital game-based learning (DGBL) for their ability to effectively deliver the concepts of heat and temperature. In this research we use quasi-experimental design with 72 participants (mean age of 19.31 and standard deviation of 1.30). They were divided in two groups (game and simulation). The data was collected by Multiple Choice Questions (MCQ type paper) in accordance with the measured graduated scale Certain Response Index (CRI). The participants of the game group had shown significant decrease of 20% misconceptions in post-test based on CRI scale as compared to the simulation group which

was only 16%. The research concludes that the sketch of misconception among students have minimized about 4 % more in case of "game group" than "simulation group". The study has been carried out in different colleges of the Lahore, Pakistan. The use of digital game and simulation in the computer-supported environment has given a positive outcome.

INTRODUCTION

Physics plays an important role in every walk of our life and its concepts are equally important to be understood clearly (Landau, 2006a). The concepts that linked with heat and temperature are predominant throughout the science curriculum at all stages of elementary, secondary, and post-secondary education. Students learn these concepts in early classes but when they reached at higher levels than more multifarious notions of heat and thermodynamics are required to learn in introductory course work, and it is normally presumed that students must have a stable grasp of such elementary concepts (Jasien & Oberem, 2002).

The concept of temperature and heat can be clarify indirectly, therefore the concept of temperature and heat cannot be comprehended easily (Alwan, 2011). In this connection, it is mandatory to search suitable methodologies to express the accurate ideology of heat and temperature.

Learning the concepts of physical world is an important benchmark for students who are accustomed to organize the cluttered knowledge into sequential acquired Knowledge. The knowledge can be transferred through the process of learning that has taken place rarely (Landau, 2006b)

In the learning process, students gain concepts and misconceptions simultaneously (Chang et al. 2008). Consequently, the researcher states that it is complicated for students to differentiate between heat and temperature accurately. It is difficult to sustain presumptions about it that they have learned in previous classes because they did not visualize the concepts, and lack of visualization coined false preconceptions among the students of Physics (2014, p. chen et).

Chen has added more that it would be denoted as conceptions which students have got from previous classes, and that rational structure intricate the resistant and compacts in the perception of students preconception (2014a) that is an actual way of the divergence accordingly from right conception of articles and topics which are advised by the professionals.

Most of the students that have kept wrong concepts of physics, for instance, considering heat and temperature (Samsudin, Liliawati, Sutrisno, Suhendi, & Kaniawati, 2014b). Furthermore, Samsudin has stated that only one third part of hundred and ninety-two students were properly capable of describing the right concept of momentum and impulse, and twenty-five per-cent were able to elaborate ideology of momentum and impulse deliberately, which led them towards wrong way on expressing and defining the

concept of momentum and impulse; the false preconceptions happened in a similar way, therefore, appropriate learning techniques would prove to help in minimizing the false preconceptions. Several studies have investigated that computer simulations and digital games can be carried out in minimizing false preconceptions (Jasien & Oberem, 2002)..

Consequently, Zachariah have stated that the digital game employed environment and simulation employed environment can reduce false preconceptions significantly for the students who want to learn physics concepts. It can be seen that the percentage of right considerate of the concepts about physics article among students in experimental class is higher can say that 79.1% (Zacharia and Olympia 2011).

The Muller elaborated that, Digital games and computer simulations found to be a source of teaching articles which is proving a helping source to change the preconception, especially to eliminate false preconceptions (Muller & Sharma, n.d.).

Moreover, Muller and Sharma in 2007 stated, that the use of digital game and computer simulation is more beneficial than the traditional way of teaching in physics, It could produce better results and considered itself a source of learning which is better way of recovering false preconception (Muller & Sharma, n.d.)..

The use of this Physics simulation and digital game on heat and temperature have achieved bunch of advantages to reduce the hazards which arise many times in the execution of practical manual scenario in school lab (Sözbilir, 2003). Consequently, it is specified intrinsically that the multimedia virtual reality mode is a supplementary technique (Muller & Sharma, n.d.). Which is economical to produce smooth variations in the wrong preconceptions. Thus, users would get understandings of the true concepts that have learned the students improperly by traditional way(Sullivan & Edmondson, 2008). In the research of Hake in 1998 he said that cooperative learning method by using digital computer game and computer simulations both are effective in overwhelming the false preconceptions like in mechanics which have conceived the high school students (Hake, 1998).

According to Samsudin, learning mechanics, heat and temperature under the umbrella of cooperative learning method is that way of learning to achieve shared goals of success (Samsudin et al., 2014a), or it can be precisely defined as cooperative learning technique is a helping source to work together in getting a common goal in the same class of students or vice versa. Hence, accommodating learning method is a way to learn and earn concepts that depend on the teamwork of the group that has engaged by the educator to mark the student learning responsible and intrinsic undertaking to their false preconceptions (Andaloro, Donzelli, & Sperandeo-Mineo, 1991). This will allow them to use of digital computer game and as well computer simulation accordingly to make their concepts fruitfully organized furthermore, clench the chaotic false preconceptions. PRISMA was selected as the framework to gather literature reporting on "The efficiency of repurposed videogames and simulation in physics education". Query for each systematic literature review queries was performed on three databases i.e., (Scopus, Web of Science and JSTOR). A total of 55 research articles were obtained. After reading titles of 55 articles 26 articles were excluded due to being irrelevant (not relevant to physics education). Abstract of remaining 29 articles were read and 11 were excluded (not in English, full text not available,

belong to other categories like IT, health, electronics, education, Science, and arts) resulting in 18 articles after filtering.

METHOD

The present research utilized a pseudo-trial strategy. Which is designed in that way, a group of 36 students have solved the Pre-test paper containing 20 multiple choice questions and

Figure1: Physics helping hand game

the same group have solved Post-test in a similar way after completing the game-play task Fig. 1 and Fig. 2 explored it in detail. Another group, which was named, as computer simulation group that is present in Fig 3.

Figure 2. Physics helping hand game

This study involves a random selection of candidates in several high schools and
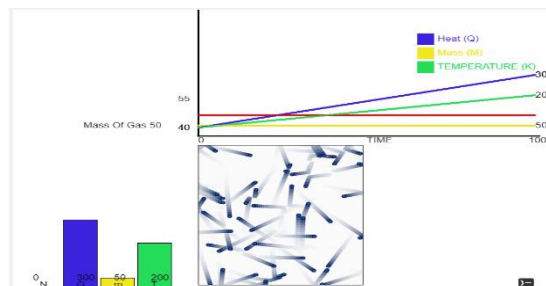

Figure 3. Computer Simulation

colleges in the area of Lahore, Pakistan. The sample is consisted of 72 students of class XI and XII. The norm was computer-assisted game-play environment for first 36 students' group and the simulation aided environment to other group to learn about the modules on

heat and temperature under the umbrella of cooperative learning method. There were given a pre-test consisting of 20 multiple choice questions to complete within 90 minutes.

The idea was to find out about the preconceptions that they have learned in previous classes about heat and temperature and in the same way, a post-test similar to pre-test have given to them in order to calculate false preconceptions This mechanism was performed with the help of such tool that was prepared in the form of Multiple-choice questions having options of four answer with additional options. Which is known as the graduated scale value of Certain Response Index from 0 to 5. Each right answer carries 1 mark and wrong answer carries 0 marks except the certain response index because it did not carry any marks. A graduated scale is called Likert scale that has used to measure wrong preconceptions left or not by regarding at the choices of answers that have given by students may answer falsely but selected the CRI scale high or vice versa. CRI was explained briefly in table 1.

Table 1. Decision matrix for an individual student and for a given question. Based on combinations of correct or wrong answer and of low or high CRI.

Criteria of Answers	Lower CRI (<2.5)	Higher CRI (>2.5)
Wrong Reply	Wrong Reply but lower the CRI value mean **did not know the concepts**	The reply is wrong but higher the CRI values mean there is a **false preconception (Misconception)**
Correct reply	The reply is correct but higher the CRI value means **don't recognize the concepts (Lucky guess)**	Reply is correct but higher CRI value means **grasping the concepts highly well**

The instrumental tool (likert scale, pre-test and post-test) has been discussed with the specialists. It is utilized after the primary survey of classes to check their preconceptions level normally to ensure that they have some knowledge about heat and temperature in all the institutions.

Strategical Design of Game and Simulation

Game Play and simulation mode have been used in that research, which is designed by using 3D Unity and java script. These programs have bunch of advantages essential for writers to maximize the on board writings and reduce the misconceptions on heat and temperature. Unity 3D and java script are such type of programs which attract the solution-

scripted environments and have been proved as comfortable application in simulating the heat and temperature concept chiefly. These programs are capable to make intellectual level good and to bring up more actual preconceptions about heat and temperature. Therefore, students took the easiest way to realize all the concepts of heat and temperature in real physical world; game that has been developed in unity 3D shows that when flame thrower throws heat on object, it, simultaneously, increases its heat and temperature which is the statement of formula to be proved. Pictorial representation of this process has been presented in Fig. (1, 2, 3.).

Game and simulation have been developed by using unity 3D and java script which is computer-assisted environment under the umbrella of cooperative learning method. Both of the Game and the simulation grounded environments have such characteristics to minimize false preconceptions about heat and temperature. The effects of such mode of learning have been developed in five areas of development called conquer rule i.e., Stating, Designing, Mounting, Propagating and Evaluation. In the phase of Stating, researchers have designed the simulation and game storyboard in unity 3D and java scripts through the programming arena. Second is designing which prepares the concept of simulated world to minimize the potential false preconceptions, for example, picking up the object and throwing flame on it changes the colour of object red to white and vice versa, it shows the effect on objects like water and wood which is elaborated by vectors in Fig. (1, 2).

The third point that has been mentioned above is emerging to design the simulation of all ideologies about heat and temperature with the same mode of learning to clear the preconceptions. Presciently, the propagating scenario is the forefront of all three mentioned steps. Finally, disseminating used to evaluate the profile of students' misconception about above five factual supports which is implemented on game and simulation about heat and temperature in collecting data to manipulate by formulas and to calculate the decrease of student's misconception about heat and temperature.

All of the gameplay and simulations were developed in the computer-assisted environment were implemented in one classroom to solve the problems of the students, game play, and simulation observation were the leading medium to minimize the complexity of problems. Students who had problems in understanding of heat and temperature were selected by exerting diagnostic test. Researchers implemented this 3D game play and 2D simulation to get a potential profile of false preconceptions against heat and temperature preconceptions. Furthermore, not merely computer-assisted game play and simulation have been applied in that classroom; it also includes cooperative learning method too. Computer 3D game play and 2D simulation which have been integrated by the cooperation of the cooperative learning method to decrease misconceptions on heat and temperature. By using computer simulations, a noticeable decrease in the percentage of misconceptions has been shown in the figure 4.

Profile of Misconceptions

The sketch of preconception had been acquired with the help of primary identification of the Pre-test and the Post-test instrument to evaluate the outcomes for each class. It can be observed easily in diagram 4. The existence of false preconception about heat and temperature is still there among the peers of class XII and class XI which have been termed as cognitive preconceptions. Two different modes of simulation and game play in teaching physics have exhibited an explicit difference among the student's misconceptions portfolios. Besides, there was no opportunity given to them to get involved in cooperative methods in previous classes to express their notions spontaneously so the students could not get the actuality of concept, therefore, they did not get accustomed with the notion that they received, the wrong concept was not the chance that they had got to explain straight forwardly.

The profile of misconception in simulation and game play earned a fractional percentage above 41%, and 39% in pre-test although it was mentioned that the fractional percentage of false preconceptions for the results of Post-test on the experimental class had the smallest value of 21.2% and 25%. Thus, it means that the knowledge to get in the experimentally designed virtual classroom was better than a conventional classroom in minimizing false preconceptions.

Figure 4 demonstrated that cooperative learning method in virtual reality based tentative class by using gameplay and java script simulation had caused major decline in false preconceptions; the pre-test misconception outcomes of gameplay was 41% and that of simulation was 39%. After the usage of cooperative learning method in post-test, the percentage of misconceptions in gameplay and simulation compressed to 21% and 25% respectively, marking the accumulative decrease of about 4%. Muller and Sharma said, "multimedia-based, of course in misconception case, is not the complete answer at all in the conceptual change." It was meant that peers who had fewer active attentions, could not undertake conceptual change as compared to an active one. It would have been an impression on a false preconception of peers that they could possibly experience. Under the effect of compliant education, students would become more active during the class and it would help them minimizing the influence of false preconceptions. Correspondingly, the student's group is required to become energetic. Then, to learn with the aid of computer-supported game-play and simulation environment is enough to get better outcomes. Without the compliant knowledge, the model of learning is impossible to learn, and it is insufficient to minimize wrong preconceptions in the improvement of clutching the concepts. We have calculated many other factors like correct concept. Do not know, lucky guess, guess and CTI.

It can be seen that correct concept has 33% bar value in (game) pre-test and 50% in (game) post-test on comparing with simulation only 34% in pre-test and 16% in post-test. Consequently, in do does not know portion the percentages are 20% in (game) pre-test and 1.25% of post-test on equating with simulation 15% in pre-test (simulation) and 13.7% in post-test (simulation). Lucky guess percentages are given as 10% in (game) pre-test and 7.5% in (game) post-test on matching with simulation 11.8% in (simulation) pre-test and

4.3% in post-test. Guess results are 20% in pre-test (game group) and 6.9% in post-test on comparing with simulation 0.1% in (simulation) pre-test and 6.8% in post-test. In similar way CTI was the section named as the students who do not fill the CRI value 10% in pre-test (game) and 1.3% in post-test and 3.1% in (simulation) pre-test and 2.1% in post-test (simulation).
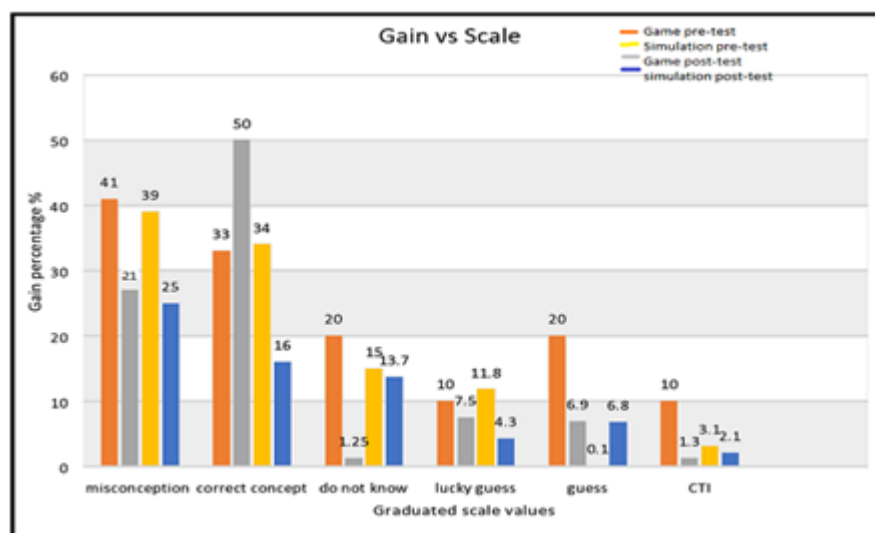

Figure 4. Results Mean of Heat and Temperature concept achievement

CONCLUSION

Technology is now playing important role in learning process; several schools and colleges are transformed from traditional to digital environments. According to the current requirements, the researchers have introduced new teaching strategies "game play" and "simulation". These teaching strategies contributes to improve the quality of learning.

According to discussion and research that has been completed, it might be clinched that the use of digital game and computer simulation under cooperative learning model have potential to minimize the student's misconception on the concept of heat and temperature. According to results (Fig.4) 41% misconception found in pre-test of "game group" though 39% misconception in pre-test of simulation group. On other hand 21% misconception have retained in post-test of game play and 25% in "simulation-group". On the matter of fact that the research work has done, it is concluded that the computer gameplay and simulation assisted environment have the dormant to minimize false concepts of Physics. Our studies showed that the "game group" have minimized the misconception 4% more than the "simulation group" on comparing the results. The Cooperative learning method and both modes of learning (game play and simulation) have better prospective to minimize the misconception of heat and temperature.

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Compliance With Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest. Ethical approval and All procedures performed in studies involving human participants were in accordance with the ethical standards. Informed consent was obtained from all the individual participants included in the study. We have not taken any resources of funding from any agency. We conducted the research on our own resources. We have selected the students voluntarily and randomly from different colleges of Lahore Pakistan. It was the informed consented research from the participants of colleges that we have conducted. Some info in the form of photographs have been taken by consenting them and it was decided to destroy completely at the end of research and that we have destroyed at all, but the consent form and demographic form is available to us which is also anonymously filled that only the signature of student is present on it. There was no conflict of interest between participants and researcher and any other agency of funding.

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