USING MULTI-MEDIA AND CLASSROOM COMPUTER NETWORKING FOR EVALUATION AND ANALYSIS

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Classroom computer networking refers to establishing a communication set-up that can be used to make classroom teaching interactive and student-centric. Our classroom networking is different from the conventional classroom communication systems (CCS) that involve use of the infra-red remote controllers. Our network based system makes use of computers and the networking device called Router. An advantage of this network based system is that it makes use of the installed software-windows operating system, for communication. In this way it proves to be more accessible and economical than other communication devices. A class of about 80 under-graduate students of 2nd semester was divided into 40 groups with two students per group. Each group was assigned a computer terminal for doing analysis and to communicate through the communication device (NETGEAR WGR614 wi-fi N150 router) with the instructors' computer. We proposed an activity namely- Newton's Cradle device, in which the concept of conservation of linear momentum is involved. Animations of this activity was prepared and uploaded on the computers. Based on the activity the students were given a questionnaire to respond and communicate to the instructor in a specified time (about 60 minutes). The questionnaire contained questions that tested a student's knowledge about basic concepts like conservation of momentum and energy etc. The results obtained by different groups of students were compiled and then analyzed. The entire procedure of evaluation was carried out in paper-less environment.

INTRODUCTION

In the under-graduate curricula, concepts of conservation of linear momentum in collisions are taught prominently in theory classes. We thought that it would be a good idea to introduce students an apparatus or an activity in which these concepts are applied. The aim of the presented work is to showcase such an apparatus and introduce an innovative method of testing students' skill of analyzing a practical physics problem. Such a method, (Wadhwa, 2013) can be very useful in analyzing various concepts of physics which require more imagination and visualization than mere theoretical or mathematical model. Moreover with the aid of animation and respective videos one can easily visualize difficult concepts which require precise experimental work to comprehend. We selected Newton's Cradle apparatus for demonstrating the concepts of multi-body collisions and the law of conservation of momentum in such systems. We constructed the actual apparatus for the activity and then made animations of the experiments along with a questionnaire. These were uploaded on 40 computers in a classroom and a computer network was established using a router.

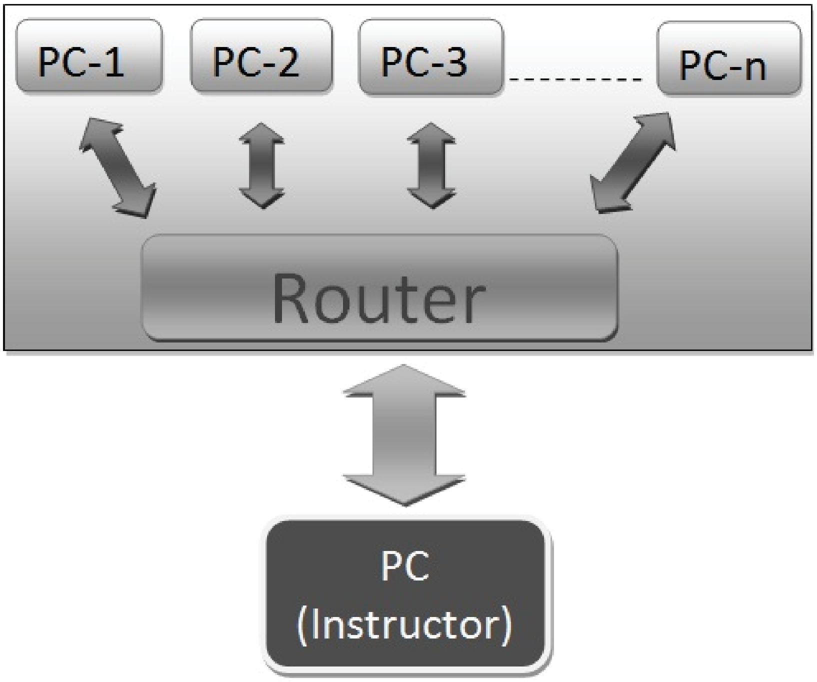

Figure 1: Classroom networking system

Each computer terminal was assigned to a group of two students who were asked to observe the two animations, analyze them and then record their answers in a text file. The text file containing answers from each of the forty terminals was communicated to the instructor's computer terminal through the local network. The arrangement of the networked system is shown in figure (1).

Previous Works

Levy et al., (2003) used the Jeliot 2000 program animation system to teach introductory computer science to high school students. They conducted a series of experiments with two batches of students with almost same intelligence level. One of the group, called animation group was taught using the Jeliot 2000 program, whereas the other group called the control group was taught without any multimedia aid. After the Statistical analysis of the pre- and post-tests, the improvements in the average grades of the animation group were significant, except for the first pair of tests. The average grades in the control group improved but the improvements were not statistically significant. Moreover the Animation Group showed more concrete understanding of dynamics of the algorithm by visualizing it, than Control Group which has to rely merely on their memory and imagination to comprehend the algorithm.

Sentongo, Kyakulaga & Kibirige (2013) used Computer Simulations in Teaching Chemical Bonding. Similar to the Jeliot 2000 experiment, they too considered two batches, namely Experimental Group (EG) and Control Group (CG) for their experiment, where the former was taught using computer simulations while the latter one was taught without it. The results of the post test showed that EG had a better understanding of chemical bonding concepts when compared to traditional hands-on (manual or laboratory apparatus handling) teaching. Computer simulations helped learners to create imaginable representations of chemical reactions much better than traditional teaching did.

Newton’s Cradle Apparatus

Newton’s Cradle is a device that demonstrates conservation of momentum and energy via a series of swinging spheres. It consists of a series of identically sized metal balls suspended in a metal frame so that they are just touching each other at rest. Each ball is attached to the frame by two wires of equal length angled away from each other. If one ball is pulled away and is set to fall, it strikes the first ball in the series and comes to nearly stop. The ball on the opposite side acquires most of the velocity and almost instantly swings in an arc almost as high as the height of the initial ball. This shows that the final ball receives most of the energy and momentum that was in the first ball.

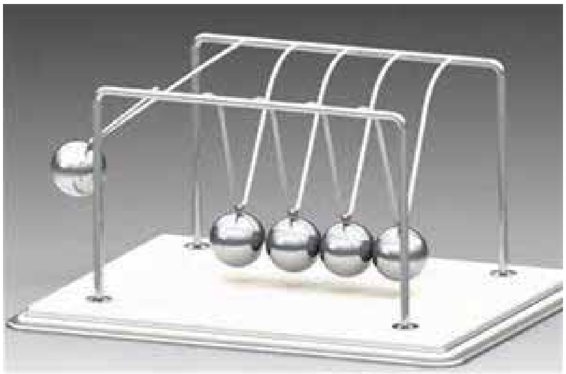

Figure 2: Newton’s Cradle

Analysis of Newton’s Cradle Experiments

For demonstrating the concepts of collisions and law of conservation of momentum, we chose the Newton’s cradle (N-C) apparatus (Hutzler et al., 2004). We used animations of this device in different configurations and prepared a questionnaire on them. The Newton’s cradle can be analyzed in two ways - the first and simplified method of analyzing is by assuming that the collisions are elastic and the steel balls always collide in pairs instantly. The second and more difficult approach is to assume elastic collisions of the five steel balls colliding simultaneously at an instant of time. The second approach has been studied using different types of mathematical models (Hinch & Saint-Jean, 1999). But we decided that with the first year college students the first approach should be appropriate. The questionnaire given to the students contained five questions based on theoretical knowledge and the rest five questions to test their practical skills. We uploaded animations of the N-C experiments on each of the students’ computers. In experiment #1 of the animation, if ball (1) is taken aside and released to strike the 2^{nd} ball, only the 5^{th} ball from the other side will leave to oscillate. Similarly in experiment #2 of the animation, if two balls (1,2) are taken aside and released then only two steel balls (4,5) together leave from the other side and begin oscillations. Amongst the various explanations given by the students, the most suitable is presented here. In this analysis we can assume that on impact, an unknown mass (M) to leave from the other side. And then determine this mass (M) using the laws of conservation of energy and momentum. For instance considering experiment #2 when two steel balls each of mass ‘m’ are taken aside, according to law of conservation of energy,

$$0.5(2m)u^2 = 0.5(M)v^2 \qquad \dots (1)$$

where (M) is the unknown mass, u is the initial speed of mass (2m), v is the final speed of (M)

Using the law of conservation of linear momentum we have $2mu=Mv$ … (2)

From (1) and (2) we get $v = 2mu/M$ …(3)

Using (3) in (1) we get $M=2m$

This shows that two balls of total mass M would leave from the other side to oscillate. Similar analysis can be applied to other cases involving three and four masses. Students were encouraged to give critical comments on the above analysis and one of these referred to the verification of our assumption that the balls suffered collisions in pairs and multiple collisions took place later on. To verify this we used audio sensor to detect sound signals on impact between the balls.

Student Questionnaires and Evaluation

Students were evaluated on the basis of two types of questionnaires as shown in figure (3). The Type-1 questionnaire contained questions on the basic theory relevant to this experiment; Type-2 questionnaire consisted of those questions that tested their aptitude in applying basic theory to a practical problem. For example, questions such as can we assume a hypothetical model of the colliding steel balls, or what kind of a force-displacement relation exist between finite-sized steel balls. The responses of the students to both types of questionnaires are shown in figure (4). In type-1, about 30% students scored less than the passing 20 marks and 25% could score between 40 and 50 marks out of a maximum 50 marks. About 50% of the students were able to score more than 30 marks which showed good understanding of basic physics. However, the situation became completely different in type-2 questionnaire as shown in figure (3). Now 80% students scored less than passing 20 marks and none could score between 40 and 50 marks out of a maximum 50 marks. About 6% of the students were able to score more than 30 marks as against 50% in type-1 questionnaire.

Type – 1	Type – 2
1. What is an elastic collision? 2. What are the laws of conversation of linear momentum (LCM) and energy (LCE)? 3. Is the LCM or both obeyed in the N-C experiments? 4. Are the collisions in the N-C experiments 1-D, 2-D, 3-D? 5. How can we determine the speed of each steel ball in the experiment?	1. What are the different ways of analyzing the N-C experiment to determine the speed of oscillating steel balls? 2. What can be the equivalent model that can be used for analysis of the N-C experiment? 3. Should we consider the set of steel balls as N-body system or a 2-body system? 4. Can we determine the speed of sound through steel from this experiment? 5. Is there any compression at the point of impact during collision?

Figure 3: Questionnaires

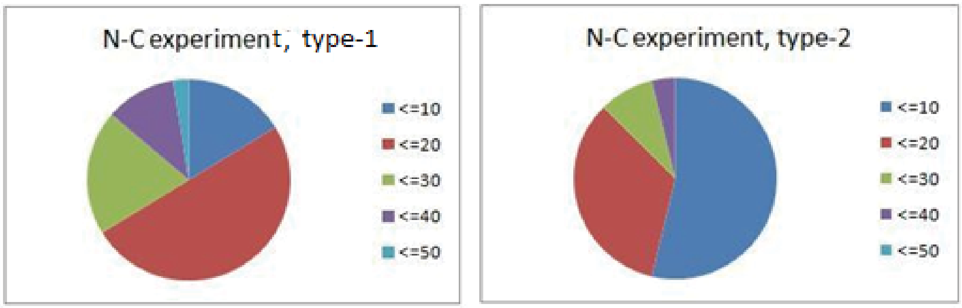

Figure 4: Comparison of student performance in N-C experiments.

CONCLUSIONS

Computer simulation and animation helps learners to create imaginable representation of a physical phenomenon. It is the conjunction with verbal narration provided by the teacher which allows learner to visualize the basic ideas and concepts of any phenomena. Furthermore animation is an educational tool that must be integrated into the classroom for testing and assignment purpose, rather than used as a one-time teaching aid.

We have presented an innovative approach towards enhancing students' learning process in the classroom by taking an example of a physics problem. For the first time animations of experiments are used and communicated in the classroom using networking via a router and existing windows o/s to collect the response of the students for evaluation and analysis.

Our results and findings actually emphasize the importance of multimedia including animation in pedagogy. As discussed in Stasko, Badre and Lewis (1993), the need is to view technology as an instrument that supports students to construct, represent, articulate and discourse about knowledge. This idea has been initiated in our experiment. From our findings we conclude that teaching through multimedia can be very effective in bringing out the strengths and weaknesses of students. By including such activities in our educational curriculum we can make classroom teaching interesting and more student-centric. The student also becomes more attentive and application-oriented in approach towards learning a subject. The communication networking in the classroom induces a sense of belongingness in all the students irrespective of their caliber.

The multimedia method of evaluation used in this work is very useful and economical.

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