INTRODUCTION

Chemistry is always a difficult and mysterious subject. It is in general a tedious task to comprehend the abstract chemical concepts specifically those of organic chemistry. It is again very difficult for average merit students to realize the symbolic dimension of the triplet model of chemical concepts viz. macro, sub-micro and symbolic (Johnstone, 1982; Gabel, 1999 and Talanquer, 2010). To understand and visualize the chemical concepts better specifically abstract symbolic part the traditional classroom interaction is not adequate (Gilbert, 2005, 2009). So, introduction and integration of technology in the classroom is a general demand in the modern technological era for appropriate learning outcome during the chemistry teaching (Abitt, 2011; Chai, et.al.2011; Young, et. al. 2012; Sathiyaraj, et.al. 2013).

Nowadays the Information Communication Technology (ICT) is very much improved and wide spread media component with the help of computer based multimedia technology. Hence, compilation of computer based multimedia teaching aids is very much important in the chemistry teaching learning process for enhanced comprehension of the abstract chemical concepts. Proper compilation of technology with teaching learning process i.e. Pedagogy and Content leads to a new educational framework; (Shulman, 1987; Harris, et.al. 2009; and Koehler, et. al. 2012, 2013) Techno-Pedagogical Content Knowledge (TPACK). Thus, computer based multimedia course material and more precisely spoken courseware is a good techno-pedagogical tool. If this multimedia courseware becomes user interactive, then it provides multisensory responses by facilitating critical, creative, analytical and innovative thinking through challenging
and thrilling experiences. Again it also can reduce the learning time with reference to input variables concerned (Ng, et.al., 2000; Hofstetter, 1995). So an interactive multimedia courseware is a strong technopedagogical tool for constructing abstract symbolic chemical concepts like isomerism, fundamental chemical effects, reaction mechanism etc. The interactive nature of these technologies offers new insight i.e. introspection into the learning procedure by facilitating independent learning to achieve high self esteem (Neo, and Neo, 20010).

**METHODOLOGY**

The effectiveness of any course is directly related to the outcome of the course i.e. the performance of the students after implementation. The key object of this study is to identify the effectiveness and the usability aspect of the multimedia courseware through a suitable post-test experimental design. A complete interactive multimedia courseware in organic chemistry for higher secondary students was developed using Photoshop, Flash and Autodesk Maya. To assess the efficiency of the interactive multimedia courseware it was employed to the students of class XI in the two reputed schools of two different boards of the Higher Secondary Education namely WBCHSE and CBSE in the Burdwan town, West Bengal, India. For this purpose two equivalent groups of students from each school were structured by matched pair design namely i) Control Group of students and ii) Experimental Group of students according to their results in chemistry in their school’s Test. The Students of Control group were taught organic chemistry by traditional chalk and talk method, while the students of the experimental group were interacted with the multimedia courseware in presence of the teachers and consulted with them. Finally an achievement test was administered on both the groups separately and the data was collected for both the schools and compared (Figure 1). In addition the students of both the groups were again categorized into intelligent and average students group by applying Cattell’s culture fair intelligent test (Cattell, R.B. 1949 and 1963).

**Figure 1: Flow Chart of the Experimental Design**

**HYPOTHESES OF THE STUDY**

**Null Hypothesis 1 (H₀₁):** There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (X₁) and the Experimental (X₂) Groups (Students of CBSE).

**Null Hypothesis 2 (H₀₂):** There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (X₁₁) and the Experimental (X₁₂) Groups of boys.

**Null Hypothesis 3 (H₀₃):** There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (X₂₁) and the Experimental (X₂₂) Groups of girls.

**Null Hypothesis 4 (H₀₄):** There is no significant difference in post-test scores in the achievement of organic chemistry between the girls and boys.

**Null Hypothesis 5 (H₀₅):** There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (Xₐ₁) and the Experimental (Xₐ₂) Groups of the average students.

**Null Hypothesis 6 (H₀₆):** There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (Xᵢ₁) and the Experimental (Xᵢ₂) Groups of the intelligent students.
Null Hypothesis 7 (H7): There is no significant difference in enhancement of scores in the achievement of organic chemistry between the intelligent and average students (categorized using Cattell’s culture fair intelligent test).

Null Hypothesis 8 (H8): There is no significant difference in post-test scores in the achievement of organic chemistry between the Control (X1) and the Experimental (X2) Groups (Students of WBCHSE).

Null Hypothesis 9 (H9): There is no significant difference in the enhancement of scores in the achievement of organic chemistry between the students of WBCHSE and the students of CBSE.

RESULTS AND DISCUSSION
In general, the students of both schools apart from gender or intelligence or different board/council, they enjoyed the Interactive Multimedia Courseware and responded in the class very well with a positive attitude in a technology oriented environment. They were very motivated, enjoyed being challenged and able to have creative input through critical thinking about the topic and use multimedia technology based software. The quantitative data collected through the post-test experimental design were statistically analyzed.

Statistics for the Analysis of Null Hypotheses

Table 1: Paired Samples Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
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<tbody>
<tr>
<td>Pair 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Experimental Group</td>
<td>69.7222</td>
<td>36</td>
<td>9.25398</td>
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<tr>
<td>Control Group (CBSE)</td>
<td>39.0278</td>
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<td>8.68656</td>
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<td>Pair 2</td>
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<td></td>
<td></td>
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<tr>
<td>Experimental Group Boys</td>
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<td>Pair 3</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Experimental Group Girls</td>
<td>68.1818</td>
<td>11</td>
<td>11.01652</td>
<td>3.32160</td>
</tr>
<tr>
<td>Control Group Girls</td>
<td>34.5455</td>
<td>11</td>
<td>6.10514</td>
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<tr>
<td>Boys’ Scores</td>
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<td>Girls’ Scores</td>
<td>68.1818</td>
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<td>11.01652</td>
<td>3.32160</td>
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<td>63.0952</td>
<td>21</td>
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<td>Control Group Average students</td>
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<tr>
<td>Experimental Group Intelligent students</td>
<td>77.6667</td>
<td>15</td>
<td>3.19970</td>
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<td>Control Group Intelligent students</td>
<td>50.3333</td>
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<td>Pair 7</td>
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<tr>
<td>Enhancement of scores of Average students</td>
<td>28.0000</td>
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<td>15</td>
<td>7.03732</td>
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<tr>
<td>Pair 8</td>
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<tr>
<td>Experimental Group</td>
<td>59.5000</td>
<td>30</td>
<td>6.99137</td>
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<tr>
<td>Control Group (WBCHSE)</td>
<td>37.1667</td>
<td>30</td>
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<td>Pair 9</td>
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<tr>
<td>Enhancement of scores of students of WBCHSE</td>
<td>29.6667</td>
<td>30</td>
<td>12.45221</td>
<td>2.27345</td>
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<tr>
<td>Enhancement of scores of students of CBSE</td>
<td>22.3333</td>
<td>30</td>
<td>9.71431</td>
<td>1.77358</td>
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Table 2: Paired Samples Correlations

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<th>Sig.</th>
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<td>Pair 1</td>
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<td>0.014</td>
<td>0.934</td>
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<tr>
<td>Pair 2</td>
<td>25</td>
<td>-0.231</td>
<td>0.267</td>
</tr>
<tr>
<td>Pair 3</td>
<td>11</td>
<td>0.507</td>
<td>0.112</td>
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<tr>
<td>Pair 4</td>
<td>11</td>
<td>0.833</td>
<td>0.001</td>
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Table 3: Paired Samples t-Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>Experimental Group – Control Group (CBSE)</td>
<td>30.69444</td>
<td>12.60118</td>
<td>2.10020</td>
<td>26.43082 – 34.95807</td>
<td>14.615</td>
<td>35</td>
<td>0.000</td>
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<tr>
<td>Pair 2</td>
<td>Experimental Group – Control Group Boys</td>
<td>27.60000</td>
<td>15.48655</td>
<td>3.09731</td>
<td>21.20746 – 33.99254</td>
<td>8.911</td>
<td>24</td>
<td>0.000</td>
</tr>
<tr>
<td>Pair 3</td>
<td>Experimental Group – Control Group Girls</td>
<td>33.63636</td>
<td>9.51076</td>
<td>2.86760</td>
<td>27.24695 – 40.02578</td>
<td>11.730</td>
<td>10</td>
<td>0.000</td>
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<td>Pair 4</td>
<td>Boys’ Scores – Girls’ Scores</td>
<td>2.72727</td>
<td>6.46670</td>
<td>1.94978</td>
<td>-1.61711 – 7.07166</td>
<td>1.399</td>
<td>10</td>
<td>0.192</td>
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<td>Experimental Group – Control Group (Average Students)</td>
<td>29.5238</td>
<td>9.47428</td>
<td>2.06746</td>
<td>25.21117 – 33.83645</td>
<td>14.280</td>
<td>20</td>
<td>0.000</td>
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<tr>
<td>Pair 6</td>
<td>Experimental Group – Control Group (Intelligent students)</td>
<td>27.33333</td>
<td>7.03732</td>
<td>1.81703</td>
<td>23.43620 – 31.23047</td>
<td>15.043</td>
<td>14</td>
<td>0.000</td>
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<td>Pair 7</td>
<td>Enhancement of Scores of Average – Intelligent students</td>
<td>0.66667</td>
<td>11.62919</td>
<td>3.00264</td>
<td>-7.77336 – 8.10707</td>
<td>0.222</td>
<td>14</td>
<td>0.827</td>
</tr>
<tr>
<td>Pair 8</td>
<td>Experimental Group – Control Group (WBCHSE)</td>
<td>22.33333</td>
<td>9.71431</td>
<td>1.77358</td>
<td>18.70595 – 25.96072</td>
<td>12.592</td>
<td>29</td>
<td>0.000</td>
</tr>
<tr>
<td>Pair 9</td>
<td>Enhancement of scores of students of WBCHSE–CBSE</td>
<td>7.33333</td>
<td>16.06739</td>
<td>2.93349</td>
<td>1.33367 – 13.33299</td>
<td>2.500</td>
<td>29</td>
<td>0.018</td>
</tr>
</tbody>
</table>

Analysis of Null Hypothesis 1 (H₀₁)

From the Post-Test Analysis of scores in the achievement of organic chemistry between the students of Control (X₁) and the Experimental (X₂) Groups in a CBSE school, it is clear that in a two tailed t-test the Null Hypothesis 0₁ is rejected as the t(35) = 14.615 is greater than t(Critical) = 2.042 at 0.05 level. So the hypothesis assumed is false in the 95% confidence level. This analysis clearly revealed that there is a significant difference in the achievement of the students of Control (X₁) and the Experimental (X₂) Groups i.e. the interactive multimedia courseware has greatly influence the students’ achievement in organic chemistry and again the mean of achievement test of the experimental group is very much enhanced than that of the control group. Hence the interactive multimedia courseware has greatly enhanced the performance of students in the organic chemistry as well as comprehension of the abstract chemical concepts.

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Analysis of Null Hypothesis 2 (H₀₂)

For the Post-Test Analysis of scores in the achievement of organic chemistry of boys, the Null Hypothesis H₀₂ is rejected in the two tailed t-test as the t(24) = 8.911 is greater than t(Critical) = 2.064, at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. This analysis clearly revealed that the interactive multimedia courseware has greatly enhanced the performance of boys in the organic chemistry as well as comprehension of the conceptual chemical knowledge.

Analysis of Null Hypothesis 3 (H₀₃)

Similarly for the Post-Test Analysis of scores in the achievement of organic chemistry of girls, the Null Hypothesis H₀₃ is rejected in the two tailed t-test as the t(10) = 11.730 is greater than t(Critical) = 2.228, at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. This analysis is also strengthened the effect of the interactive multimedia courseware on the performance of girl students by assisting abstract visualization of chemical concepts.

Analysis of Null Hypothesis 4 (H₀₄)

In this Post-Test Analysis, comparing the girls’ scores and the boys’ scores in the achievement of organic chemistry, the Null Hypothesis H₀₄ is accepted in the two tailed t-test as the t(10) = 1.399 is lesser than t(Critical) = 2.228, at 0.05 level. So the hypothesis assumed, is true in the 95% confidence level. So the effect of the interactive multimedia courseware on the performance of girls and boys is almost equally effective i.e. the interactive multimedia courseware can enhance the performance students irrespective of any gender effect.

Analysis of Null Hypothesis 5 (H₀₅)

The Cattell’s culture fair intelligent test was administered on the students of both the control and experimental groups and those scored IQ above 110 were categorized as intelligent while those scored IQ below 110 were categorized as average students group. Here in the Post-Test Analysis of scores in the achievement of organic chemistry of average students, the Null Hypothesis H₀₅ is rejected in the two tailed t-test as the t(20) = 14.280 is greater than t(Critical) = 2.064 at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. Thus this analysis clearly revealed that the interactive multimedia courseware has greatly enhanced the performance of average students in the organic chemistry.

Analysis of Null Hypothesis 6 (H₀₆)

Similarly for the Post-Test Analysis of scores in the achievement of organic chemistry of intelligent students, the Null Hypothesis H₀₆ is rejected in the two tailed t-test as the t(14) = 15.043 is greater than t(Critical) = 2.145, at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. This analysis is again strengthened the effect of the interactive multimedia courseware on the performance of intelligent students by assisting abstract visualization of chemical concepts.

Analysis of Null Hypothesis 7 (H₀₇)

In this Post-Test Analysis, comparing the enhancement of scores of the intelligent and average students in the achievement of organic chemistry, the Null Hypothesis H₀₇ is accepted in the two tailed t-test as the t(14) = 0.222 is lesser than t(Critical) = 2.145, at 0.05 level. So the hypothesis assumed, is true in the 95% confidence level. So the effect of the interactive multimedia courseware on the performance of the intelligent and average students is almost equally effective i.e. the interactive multimedia courseware can enhance the performance students irrespective of their IQ.

Analysis of Null Hypothesis 8 (H₀₈)

The experiment was carried out again in a Bengali medium school under WBCHSE with the Bengali version of the courseware and the result is same. The Post-Test Analysis for scores in the achievement of...
organic chemistry between the students of Control ($X_1$) and the Experimental ($X_2$) Groups in this school revealed that the Null Hypothesis $H_0$ is rejected in the two tailed t-test as the $t(29)=12.592$ is greater than $t(\text{Critical})=2.064$ at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. Thus the interactive multimedia courseware is also equally effective in Bengali medium school too.

**Analysis of Null Hypothesis $H_{09}$**

In this Post-Test Analysis when the test scores of the two schools viz. WBCHSE and CBSE were compared, it was found that the Null Hypothesis $H_{09}$ is rejected in the two tailed t-test as the $t(29)=2.500$ is a little bit higher than $t(\text{Critical})=2.045$, at 0.05 level. So the hypothesis assumed, is false in the 95% confidence level. So there is significant difference in the performance of the students in the organic chemistry between the two schools and more precisely as the mean of the achievement test of the students of school under CBSE is higher than that of the school under WBCSE, so it can be inferred that the interactive multimedia courseware enhance the performance in organic chemistry of the students of school under CBSE. This fact raises one question that why the performance of the students of school under CBSE is higher than that of the school under WBCSE. The answer is techno-pedagogical competency,- the ability to utilize technology efficiently in the classroom- which must be higher in the teachers of school under CBSE than the latter case.

**CONCLUSION**

The results of this experimental research clearly proved that the interactive multimedia courseware is a very good tool to provide a great support to enhance the achievement in organic chemistry of secondary students irrespective of gender, intelligence and board/council. But to convert this tool into an effective techno-pedagogical tool student who are interacting with this tool must have readiness and the associated teachers should have sufficient techno-pedagogical competency to facilitate them in a well equipped technology oriented class. Further to make it popular and more usable someauthoring characteristics of the courseware have to be increased as well as new one may be introduced to stimulate multisensory responses by facilitating critical, creative, analytical and innovative thinking through challenging and thrilling experiences in a technological environment. In addition, to be successful in such endeavors, there must be adequate number of computers made accessible to the students and teachers, in order for this type of course to be appropriately carried out. And finally, training in this software should be provided to the teachers to enhance their techno-pedagogical competencyso that they can conductthese types of classes smoothly.

**REFERENCES**


Cattell, R.B. (1949). *Culture Free Intelligence Test, Scale 1, Handbook*. Champaign, IL:: Institute of Personality and Ability Testing.


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Sibananda Sana  
Department of Chemistry, Government Training College, Hooghly, West Bengal, India.