
Importance of Computer Assisted Teaching & Learning Methods for Chemistry

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Abstract: Understanding the basic concepts of chemistry is very important for the students of secondary school level and university level. The Computer Assisted Teaching and Learning (CATL) methods are marked by the usage of computers in teaching and learning processes. Usage of WORD, EXCEL, POWERPOINT, ACCESS, PHOTOSHOP etc., as well as the use of specialized packages such as CHEMDRAW, SCIFINDER etc., can be worth mentioning. The role of internet in feeding the thirst of students is comparably far better than the classroom teaching. By the use of CATL methods, students can acquire high quality of mental models.

Keywords: CATL, Computer, Internet, Multimedia, Cognitive Load, Audio, Video, Mental Models

1. Introduction

The teaching and learning of chemistry is found to be difficult in recent times. This is because of the poor understanding of the basic concepts which has to be visualized mentally. Computer Assisted Teaching and Learning (CATL) methods will help to overcome the teaching as well as learning processes [1]. Though a large number of computer applications are available, the use of PowerPoint presentation, animation, audio, video and multimedia presentations are worth mentioning [2,3,4,5]. The purpose of this study is to unfold the importance of using CATL methods.

2. Aim and Scope of the Study

2.1. Aim and Scope

The aim and scope of this study is to highlight the importance and significance of the usage of CATL methods in chemistry. The scope of this work is to set forth a platform for students to utilise the assistance of computers which could enable them for internet based teaching and learning. The rapid developments of computers are leading to the emergence of an information based society. These changes have created great impacts in our lives including the way we learn and think. If computers used appropriately can facilitate students' collaboration and enhance knowledge building. Almost all

teachers and students would be willing to use new technology in teaching and studying. The infusion of computers into education is gaining popularity as an effective platform for enhancing the teaching and learning process.

The role of computers in education is commonly associated with the process of educational innovation. The more technologically-innovative is the information delivered to the students, the better their retention and attention levels will be. Use of computers in the learning process will bring a major shift in the education paradigm that promises advantages over the conventional learning system where, computers in education is slowly taking over those traditional teaching aids such as the overhead projectors, photographic slides, charts and many others. The advantages of computers over the other teaching aids include: (a) the ability of the computers to store and manipulate a large amount of data within a matter of a few seconds. (b) Computers can also 'interact' with users/students by the use of appropriate software. (c) A computer is also flexible in that it may act as an overhead projector, charts, tables, slides all rolled in one. (d) With the increased availability of education of material and software, computers could be applied within the whole range of the school curriculum.

2.2. The Goals of Introducing Computers into Education

The goals of introducing computers into education are: (a) to keep the education system at the forefront of technological development and students' skills up to date with those

expected in the workforce. (b) To increase efficiency and productivity in teaching and learning. (c) To enable more self-directed learning with students as active learners assisted by teachers to construct their own understanding. Computer simulation and animation are usually excellent tools for education. With the visual power of simulation available in a computer, it can generate images which can help students to understand "Why things are the way they are". By using computers in instruction, information can be displayed effectively which enables students to understand concepts easily, especially concepts that are abstract which could be made easier through graphics and computer animation with multimedia effects.

2.3. Multimedia Applications

Multimedia applications are able to arrange the information into facts that are non-structured which would enable students to achieve or get information on their own. The success of multimedia technology has revolutionized teaching and learning methods from the traditional teacher-student classroom to a virtual setting. The role of the educator will evolve into that of facilitator and knowledge director while the students become more independent learners, critical thinkers and better team players and collaborators, with the skills to solve problems and seek information. Multimedia technologies help students to develop a wider and deeper understanding of the subjects they are learning. Interactive software can also stimulate the utilization of higher level thinking skills. This aspect provides a rich and powerful set of tools where students can use to test and investigate theories of their own apart from progressing through any lesson in the software. The present generation requires an extra skill, namely technology literacy in order to survive in this technology-based era. Therefore, as an educator in this age of digital information and technology, our boundaries for teaching have been expanded to the point that teachers not only have to be proficiently knowledgeable in their fields but also skilled in technologies that are being used to convey the information. With the emergence of countless technologically sophisticated tools and devices in our lives now, there is a serious need to produce computer skilled future generation urgently. Computers are used for deeper learning and that support a challenging curriculum will result in improved teaching and learning, increased student motivation and higher levels of student achievement. There is no doubt that the future trend in educational methodology and strategy is towards integrating technology into the classroom rather than the traditional strategy which emphasises on drilling and memorizing facts. It would be a tremendous advantage for students and teachers alike to exploit the full potential of multimedia and computers so that the learning environment becomes more productive and efficient. One of the goals of research in chemical education is to provide information on how chemistry can be meaningfully introduced to students, to identify the causes of impediments to learning chemistry, how learning and teaching chemistry occurs in the classroom settings and how teachers can improve their instructional

techniques in an attempt to promote better chemistry education. Educators have to accept changes in their interactions with students and have to support students as their roles changes. Therefore, teachers need to be armed with the necessary knowledge and skills to stimulate the learners and to develop their technological skills. Chemistry is a complex subject and understanding chemistry is characterized by a wide variety of dimensions of knowing, and understanding the complexity of interaction between them. Chemistry needs to be understood from a variety of interacting perspectives. Thus, teaching chemistry requires unique demands. Chemistry teachers have to be smart to use the most appropriate strategies to ensure the understanding of concept by students. In most cases, to make students understand invisible concepts, visualization is imperative. Visualization is extremely important since the subjects deal with atoms and molecules which are invisible. Over the centuries, different models have been produced to help scientists, students and the general public visualize the invisible. Recently, when we talk about chemical visualization, we typically mean computer models. Computer-assisted inquiry approach could engage senior secondary level students in meaningful chemistry learning and higher-order thinking.

3. Discussion

3.1. Softwares and Packages

Understanding the basic concepts of chemistry is very important for the students of secondary school level and university level. However many students find it difficult to understand chemistry. Their knowledge in chemistry is not up to the mark because of their misconception of scientific facts related to chemistry. Many of them are still rely on their memory power to excel in chemistry instead of understanding the basics. This poses a big threat to the development of chemistry as an important part of emerging science[6].

The Computer Assisted Teaching and Learning (CATL) methods are marked by the usage of computers in teaching and learning processes [7,8]. Usage of WORD, EXCEL, POWERPOINT, ACCESS, PHOTOSHOP etc., [Figure 1] as well as the use of specialized packages such as CHEMDRAW [Figure 2], SCIFINDER [Figure 3] etc., can be worth mentioning. Since the computer field is exceptionally expanding the above list is not conclusive.



Figure 1. Shows few icons of Microsoft softwares



Figure 2. shows the icon of Chem Draw package



Figure 3. shows the icon of SciFinder package

3.2. Word Processing in Education

3.2.1. Why Teachers Use Word Processing

Perhaps no other technology resource has had as great an impact on education as word processing. Not only does word processing offer high versatility and flexibility, it also is "model-free" instructional software; that is, it reflects no particular instructional approach. A teacher can use it to support any kind of directed instruction or constructivist activity. Since its value as an aid to teaching and learning is universally acknowledged, word processing has become the most commonly used software in education. It offers many general relative advantages (unique benefits over and above other methods) to teachers and students. Word processing helps teachers use preparation time more efficiently by letting them modify materials instead of creating new ones. Writers can also make corrections to word processing documents more quickly than they could on a typewriter or by hand. Materials created with word processing software look more polished and professional than handwritten or typed materials do. It is not surprising that students seem to like the improved appearance that word processing gives to their work. This is especially possible with the many templates that are part of the software suites today. Word processing allows materials to be shared easily among writers. Teachers can exchange lesson plans, worksheets, or other materials on disk and modify them to fit their needs. Students can also share ideas and products among themselves. Especially since the release of Google Docs, teachers and students can now create, edit, and share documents synchronously.

Generally, word processing seems to improve writing and attitudes toward writing only if it is used in the context of good writing instruction and if students have enough time to learn word processing procedures before the study begins. Students who use computers during writing instruction produce written work that is about 0.4 standard deviation better than students who develop writing skills on paper. When students write with computers, they engage in the revising of their work throughout the writing process, more frequently share and

receive feedback from their peers, and benefit from teacher input earlier in the writing process.

3.2.2. Issues in Using Word Processing

Educators seem to agree that although word processing is a valuable application; its use in education can be controversial. Word processing software designed for young children is available, and schools can introduce word processing to students as young as 4 or 5 years old. Some educators feel that word processing will free students from the physical constraints of handwriting and free them to develop written expression skills. Others worry that it will make students unwilling to spend time developing handwriting abilities and other activities requiring fine-motor skills. While no researchers have conducted formal studies of the impact of frequent word processing use on handwriting legibility, computer users commonly complain that their handwriting isn't what it used to be, ostensibly because of infrequent opportunities to use their handwriting skills.

Some organizations have students answer essay-type test questions with word processing rather than in handwriting. Many school districts also allow students to word process their writing tests. This practice introduces several issues. It is found that students' word processed compositions tend to receive lower grades than handwritten ones do. This surprising finding indicates that educational organizations that allow students to choose either handwriting or word processing must be careful to establish guidelines and special training to ensure that raters do not inadvertently discriminate against students who choose word processing.

Teachers and administrators are still deciding how best to deal with these issues. Despite these obstacles, education's dependence on word processing continues to grow.

3.3. MS EXCEL for Chemistry Education

Basically, spreadsheets are based on Microsoft Excel. The use of Excel spreadsheets has been extensively reported in the educational journals and conferences. The results of these studies have pointed that MS Excel program is very useful in chemistry teaching due to its extensive ability in processing and presenting data. The simulation of gas chromatography experiment from mass spectrometer using the Excel spreadsheet program showed that integration of spreadsheet program in teaching mass spectrometry has helped students who have difficulties in understanding the idea and utility of mass spectrometry. Excel could be used as a teaching tool because of its ability to solve a variety of chemistry problems including calculation and plotting of graphs. Topics that normally use Excel include kinetics, titration curves, isothermal gas law and calculations of atom/molecule orbital. It is opt to point out the following advantages in using Excel spreadsheets in chemistry teaching:-

- Students could concentrate on the chemistry concepts related to experiment rather than wasting their time to do calculations.
- Students involvement have increased
- Students could test questions/models with many data

using Excel.

Excel spreadsheets can be used to illustrate the pH titration curve between strong acid and strong base; strong acid and weak base and strong base and weak acid.

Excel can be used to carry out a different study on Group theory calculation for molecular vibration. It is found that the use of spreadsheet can help students to better understand the application of theory in practical works. Using Microsoft Excel in stereochemistry for complexes with five coordination where geometry for a phosphorus complex can be calculated. Students may be given the length and bond angle of that complex and then asked them to find the bond angle between each atom in that complex in order to determine its geometry and give explanation on the factors that support the geometry they obtained. Students can perform a study on the interaction and inter-molecular combination of a complex molecule by setting molecular models using MS Excel. Most students found such activity very interesting, thus they put more effort in preparing their reports.

Using this spreadsheet program, relative molecular mass for a molecule can be determined. This function is also a useful tool in chemistry for the preparation of a solution with certain molarity.

Microsoft Excel program can be used to plot a non linear curve thereby the importance of the use of spreadsheet program in plotting non-linear curves which needs to be learnt by students will be understood. The use of Excel spreadsheet in nonlinear regression analysis indicate the use of Excel for this purpose is convenient as this program is readily available compared to the use of computer programs written in traditional programming languages like Basic or FORTRAN.

MS Excel was also successfully used in kinetics studies. The graphical functions in Excel could illustrate the kinetics of enzyme, mechanism of reaction and relate chemistry phenomena with mathematical equations well. Students may be taught to determine the best fit values of V_0 , V_∞ and k using a curve fitting solver. MS Excel spreadsheet enables the calculation of the k value for different extents of reaction and if a well-established relationship between the measured property and concentration is known, one can assess the adequacy of a first order behaviour. It can also be used to solve pseudo-first order conditions or easily changed to address different reaction orders. The tools provided in their spreadsheets can perform all the tasks above effectively. MS Excel Solver can be used to demonstrate the use of a least-squares curve-fitting technique for volumetric analysis using microelectrodes. It is found that the application of curve-fitting techniques using MS Excel Solver a useful method of introducing students to concepts in volumetry through practical experience.

Students enrolled in both general chemistry for majors and general chemistry for non majors can be introduced to Excel spreadsheets with the purpose of increasing their understanding and appreciation of solubility and some of its ramification. Thereby students will be very satisfied with the new learning technique since the activities gave them opportunities to learn more about solubility in addition to

developing their mathematics, computer and graphing skills. MS Excel spreadsheet could help in the simulation of linear-molecule spectra to explore the dependence of rotational band spacing and contours on average bond lengths in the initial and final quantum rotational states. The use of the MS Excel spreadsheet program here enables students to do a mathematical "experiment". Students can attempt to perform Restricted Hartree-Fock SCF calculations using MS Excel on a two body, two-electron system, which make use of standard minimal Gaussian basis sets for hydrogen and helium to explore the tendency of the underlying self-consistent field (SCF) procedure in computational chemistry.

Spreadsheets have been shown to be able to help students save time in plotting graphs and doing the calculations. Students can spend more time discussing chemistry concepts rather than doing the calculations. Also it is found that spreadsheets can be very effective in processing data and the results could be displayed in a most attractive manner.

Calculations that were once considered complicated and time consuming are now becoming routine with minimum effort. The revolution of spreadsheet program since 1970s until the emergence of Windows has made MS Excel the most widely used spreadsheet application worldwide. The powerful and user friendly features in the recent version of MS Excel that shows pedagogical potential have been extensively reported in the educational literature. Hence, chemistry teachers should be made aware and encourage to use this 'world ware' tool to enhance their pedagogical capability and ability. If they can be convinced and enabled to create their own teaching and learning materials of chemistry that meet the learners' needs and enhance the learners' capability, students' interest in learning chemistry will be greatly improved.

3.4. CHEMDRAW for Chemistry Education

This application helps Chemistry teacher get students more engaged in class and more involved in the learning process. Chemistry can be a challenging topic for some students, as it requires the mastery of abstract concepts that are important in understanding molecular structure, physical properties, and complex chemical transformations. Chemistry requires hands-on learning from working out complicated chemical reactions to executing experiments in the laboratory, students learn best when they are working the material. Rather than simply lecturing to the students, one has to give them in-class problems to work so that he can track how well the class is absorbing the material that is presented. Most students not even working the assigned in-class problems; the majority of the class would just wait for the usual suspects to raise their hands and provide an answer. When ChemDraw was introduced to students, it became a quick and easy way for all of the students to work on in-class problems and submit their answers. Importantly, the sharing capabilities of the ChemDraw application allowed for anonymous submissions and this provided comfort for all students to participate. From this perspective, ChemDraw figuratively allowed every student to work the problems. ChemDraw has also helped

students when studying outside of class. With this application and the Flick-to-Share technology, they are able to save and share molecules and reactions with each other. This has created virtual study groups that have helped the students collaborate better, which has resulted in greater teamwork and discussion amongst pupils. As an educator, it is rewarding to watch the students learn from each other, and ChemDraw makes this possible.

ChemDraw helped students become more engaged in the course material, and more involved in the classroom experience. ChemDraw was a positive addition to classroom to see how future students benefit from the application.

3.5. SCIFINDER for Chemistry Education

There is a need to use SciFinder in teaching undergraduate laboratory courses. One has to develop a specific lab assignment that focuses on SciFinder. Typically organic labs have literature search assignments. The undergraduate class assignments proposal would be difficult to handle. SciFinder is an immensely valuable tool. However most Organic lab courses use Brillstein to teach structure searching. As for the teaching lab there might be better tools for the undergraduate labs. ChemNetBase has files that are more useful for the organic labs and probably the freshman labs as well. Some students might use SciFinder to better advantage, but there are other things that would be as suitable for them as well. Part of our role as chem. info educators is to train people to pick and use the most appropriate tool for a given need. To turn freshmen loose on SciFinder doesn't seem to be meeting that role very well. Also we aren't set up very well in terms of computers in the labs - certainly not enough for a whole class to search SciFinder. The faculty wants the students to be working on topics of the faculty's choice and not be restricted to just topics in an abridged database - they want the students using the real thing.

3.6. Student Centered Learning Process

The use of three levels of representation such as macroscopic level, molecular level and symbolic level is very important for the understanding of the concepts in chemistry [15]. When CATL methods are used students can correlate between the three levels in learning and understanding chemistry. For high school students CATL methods are used to teach the concepts of titration in 1980's [16]. Because of the introduction of CATL methods, teachers are actively participating in the teaching process and students are interestingly participating in the learning process. Thus the learning process shifts from teacher centered learning to student centered learning. By the use of CATL methods students can acquire high quality of mental models [17, 18].

The role of CATL methods in student centered learning is to provide tools whereby the student's comprehensive ability can be increased. They won't remain passive now instead actively participate in the process such as problem solving. With the help of CATL methods the thoughts and images of the students about the chemistry concepts can be rearranged or modified.

It is known that the collaborative learning method benefits students in their learning process [14]. Usage of CATL methods provide students room to work together. They can communicate and discuss with each other and get clarified of their doubts thereby they can enhance their level of understanding towards chemistry concepts. This gives students the chance to exchange information and build a body of common knowledge.

3.7. Training the Teachers on CATL Methods

Using CATL methods are of vital importance today. Some of the teachers think that these swallow their precious teaching responsibilities. Under such circumstances teachers should be provided with scientific explanation about the need of such methods besides their conventional methods of teaching. However, the hindering block in the usage of CATL methods is teacher's knowledge in using such techniques. Teacher should be educated not only about the technical information but also about the way to choose the right method and right strategy. CATL methods can avoid the risk of exposure to unwanted chemical reactions that has to be carried out, merely for the purpose of understanding the chemistry principles.

The serious risk encountered in the use of CATL methods in the classroom is the failure of teachers to effectively integrate these methods with their teaching and learning processes. Teachers should be provided hand on experience in using CATL methods. The training session should be based on learning through doing model. Competent and skilful persons should be involved in giving such training process. Teachers should be provided with an environment that is conducive for their learning process of specialized softwares. In such training programs concrete examples should be presented to the teachers who are participating as trainees. The training must be in such away to impress the teacher trainees about the effective and productive use of CATL methods in their classroom. Teachers may be encouraged even with incentives to use the CATL methods in their classrooms. Administrators and higher authorities should encourage teachers to use CATL methods in their classrooms.

4. Concept of Cognitive Load

CATL methods should be designed to serve the pedagogical purpose. Design must consider both a student's prior knowledge and the development of knowledge over the course of the student's learning process. Moreover the design of CATL methods should consider the advantages that will be made available to curriculum as well as respond to the needs of the students.

The fact to be remembered here is that if a teacher is to benefit from the use of CATL methods in the transfer of knowledge, the information provided by means of those CATL methods must be appropriate to the student's level of knowledge. Another matter to be considered in the design of CATL methods is cognitive load. The concept of cognitive load is defined as the mental cost of what is necessary to achieve activity in an individual's cognitive system [19].

CATL methods should not be designed to create an extreme load for the student's cognitive system since memorization is influenced by extreme cognitive loads[20].

5. Conclusion

Chemistry teachers must make much effort to create an ideal environment for teaching and learning by incorporating a few or more of CATL methods. Designers of chemistry curriculum as well as chemistry teachers should take care to plan and implement activities that include CATL methods in accordance with pedagogical objectives since the structure of such activities will be meaningfully effective in a student's learning process. Researchers in chemistry education may benefit from dual coding theory and cognitive load theory through studies on the influence of CATL methods [20, 21]. Although these theories are familiar to researchers in cognitive psychology, they are not adequately known in chemistry education. Finally information and communication technologies present significant opportunities in the near future for the chemistry education programs.

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