INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH AND TECHNOLOGY
ISSN 2582-7358
Impact Factor 6.328
Peer-Reviewed Journal

Using Interactive Courseware as an Effective Approach to Address Misconceptions in Acid-Base Chemistry

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Abstract

The concept of acid-base chemistry is an important one in the study of chemistry but students experience a host of difficulties in comprehending this concept hence continue to develop poor conceptual understanding. The object of this paper is the analysis of interactive courseware as an efficient instrument in correcting these misconceptions. Selected teaching and learning activities such as dynamic simulations, problem-solving, and implementation of other forms of courseware provide an enriched and loin practical approach than teaching-learning strategies. The paper analyses how well the interactive courseware assists students to learn about topics such as pH, strength of acids and buffering capacity; and assesses the effectiveness of the tool in improving students' conceptual knowledge. From the literature study, case description and experiment, this paper illustrated how interactive learning can amend misconceptions, improve retention and promote meaningful learning of acid-base chemistry.

Introduction

Chemistry of acid and base is one of the most important topics in first year general chemistry which forms the basis for most of the chemical areas and sciences. This means mastering properties and reactions of acids and bases amongst other factors that include the pH scale, strength of acids, and those systems known as buffer systems. However, students fail to understand the broad concept as well as most of the concepts related to acid-base chemistry are rather delicate and intricate. This difficulty is further compounded by the fact that many learners will have developed faulty mental models as they grapple with these ideas. Acid-base chemistry misconceptions are therefore a varied lot, ranging from the simple in nature, that involves wrong notions about the basics of acids and bases on one hand or the other, to very complex wrong notions, those concerning equilibrium and the interdependence between concentration and pH.

Misconceptions in Acid-Base Chemistry

1. **Nature of Acids and Bases:** Some of the main misunderstandings are the fact that all acids are strong and all bases are weak or that all acids are weak and all bases are strong. Truth be told, the concept of how strong an acid is determined by the extent to which it will ionise in water, and how strong a base is relative to its ability of accepting a proton or donating an electron pair. Some of these misconceptions surfaces when student are solving problems involving weak acids and bases in areas like buffer systems or titrations.

2. **The pH Scale:** This is an area that students tend to experience some difficult particularly in understanding what is referred to as pH which is a logarithmic scale that shows the number of hydrogen ions in a particular solution. Some students make a misunderstanding that pH can be put on the linear scale, or that alteration in pH really indicates the changes in proton concentration in exponential terms. For instance, the variation by one pH means a ten fold variation in the proton concentration and such variations can be in simple terms hard for the students to comprehend let alone make calculations on unless some personal computer aided learning is incorporated.
3. **Acid-Base Equilibrium:** Some of the more complex concepts, such as the concept of acids and bases … acids and their conjugate bases, or bases and their conjugate acids equilibriums … are in equilibrium in the solution. It is not easy for students to grasp that this equilibrium is capable of running forward and backward and that changes in concentration of acids and bases do not tell us about the strength of the acid or base but the relative concentrations of species at that stage of equilibrium. Also the idea of 'Ka' which is the acid dissociation constant can be reasonably hard for many students, again, to use and understand in practice, for instance in buffer solutions and titration graphs.

However these misconceptions not only interferes with the way that the student is able to ask questions and solve math problems, how they respond but it also impacts the general conceptual knowledge of students. Should these misconceptions remain unchecked, the student may well be unable to employ molecular concepts with reference to acid-base principles in more complex areas such as reaction mechanistics, biochemistry or environmental chemistry, area where understanding of acid-base behavior is critical.

Limitations of Traditional Teaching Methods

Chemistry classes have for a long time been dominated by the fall of traditional teacher centred approaches to teaching, which although has some advantages is also faced with a number of challenges in handling misconceptions. Although lectures are clear in terms of providing learners with required theoretical background, they may do not possess enough interaction and visual components that will allow the learner to touch the hypothesis or concept with a bargepole. Texts focused on acid-base chemistry as an example of a process based on abstract molecular interactions and complex balance of chemical reactions mostly cannot be explained with words or by means of a simple two-dimensional illustration. For instance, while introducing the pH scale, even if one gives a definition regarding hydrogen ion concentration, this may not help the students to understand the concept enough for instance when they can't draw a one-one correspondence of protons to pH. In the same way, concepts like the equilibrium constant or the change of the position of equilibrium in the presence of an acid or a base are hardly possible to teach without the help of dynamic concept map or simulation. Traditional methods also do not enable a student to get a quick feedback on what they have learnt as they can be seen to do under computerized methods. Some facts remain unrealized due to hope that a mistake was made on the short-term basis, students do not receive prompt feedback and do not learn their mistakes despite they are clear and will remain with them for the long-term timeframe. It is for this reason that homework assignments that are usually done at home and quiz that is usually conducted after a few weeks may be useful in identifying areas of difficulty though they are too delayed. In addition, lectures themselves are mainly one pace and one message, and do not lend themselves to, say, remedial teaching for those who are slow at understanding.

The Promise of Interactive Courseware

The progressive development in the field of educational technology indicates that there has been emergence of new ways of teaching through use of interactive courseware as a remedy to the above traditional teaching methods. Computer based instruction brings together multimedia elements such as video, animation, simulation, quiz and others for used in designing an interesting and informative course. As such, the provided tools, which enable students and learning they are applying to create an easily manipulable visual representation of some of the concepts in acid-base chemistry, can be seen as significantly more effective at helping correct misconceptions and improve the understanding, both short-term and long-term, than the traditional means of lecturing and testing. For instance, simulations of experiments such as determination of hydrogen ion concentration with pH or of the effect of conditions on acid-base reactions enable students to appreciate concepts of equilibrium in a practical way. Students may control parameters like acid concentration or temperature with easy control of apparatus and monitor the immediate effect on pH or position of equilibrium thus having a practical view of the concepts. This form of Public Many from Variables offers the student a direct role in the placement of the different contexts and offers a concrete baseline for the understanding of acids and bases from which abstract considerations can be conceived. In addition, use of interactive courseware entails instant feedback which assists the student in identifying their mistakes while making them. For instance, while answering questions of pH or equilibrium calculations, the students are provided with instant response along with the hints/explanation for their mistakes. Such kind of feedback in real time provides for a more active learning process and students construct a better mental model of how acids and bases operate. Interactivity in courseware also enhances differentiation of learning. From the lesson, learners can visit modules or exercises that they feel they need to practice more and those that they found hard to follow. On the same note, the faster learners can be moved to a higher grade level so that everybody can have equal learning experience.

Improving Student Understanding and Learning Outcomes

The first objective of applying interactive courseware is enhancing the students' comprehension of and performance on, the containing material, which in this case is acid-base chemistry. Courseware thus enables students to learn without making faults and ultimately build substantive knowledge expounded by the model. The use of these tools involves a lot of engagement and creates an environment where students can relate what they learn within the class with real life situations. Furthermore, the constant use of simulation and problem-solving approaches ensures that the students can apply the knowledge gained inany other capacity that they come across guarantees their comprehension of the core concepts. In particular, it was established that students who engage in using interactive courseware have better grades and enhanced retention of the content. Bodemer et al. (2010) revealed that the more interactive the learning environments are, the higher the level of conceptual change and problem-solving abilities of students were and this notion applied more to disciplines that were complex such as chemistry. Other research, including that by Karsenti et al. (2012), demonstrated that the use of this and other interactive tools enhances the educational effectiveness, drives misconception clarification, and increases students' interest. In addition, there is the possibility of raising students' motivation and interest through the use of interactive courseware. Chemistry, and especially the acid-base chemistry concepts, can be seen as cumbersome and distanced, which is why the common interest is missing. Through these form of teaching, students will not only be encouraged to learn in an interesting way that will make learning fun but also increase their self esteem and motivative to learn.

Literature Review

An increasing number of studies show that the technology enhanced communication helps to teach chemistry and the misconceptions students often have. Technology aided learning systems such as computer simulations and interactive learning have been discovered to bring substantial improvement in students' comprehension of chemical concepts due to the dynamic and graphical experience which are sometimes afforded by these technologies and that are could not be as easily offered by more conventional teaching and learning methodologies. It has been established that the misconceptions affecting chemistry which especial accreditation in subjects such as acid-base chemistry are fully embedded in the students. These misconceptions cannot be easily eradicated from students via normal teaching techniques such us lecturing since they are end products of a student having developed and created wrong mental representations on some concepts in his or her knowledge processing. For instance, students may understand that a strong acid consists of high density of Ion H, or that pH scale is a straight line. These conceptions can help prevent students from applying chemical principles properly, and can limit misconceptions that are hard to overcome with instruction. According to Vosniadou there is a significant difference between misconceptions and simple knowledge deficits, students misconceptions are interconnected into the conceptual models and frameworks and it takes more elaborate and participative approach to invoke a change of perspective in the student.

Interactive courseware provides a different paradigm in which students can build, experiment with, calculate, and observe changes and outcomes, and it is the feedback that is given immediately that is so important when it comes to setting right the misconceptions. Here, for instance, students are able to interact with the materials at a hands-on level to satisfy Grübler's interfaces and know the direct difference that alterations in concentration, temperature or any other factor would make to the acidic or basic reaction. Through the use of such simulations, student gets a chance to manipulate different situations in the classroom, and this can never be achieved through use of text books or diagrams. Bodemer et al. (2010) also evaluated the use of interactive courseware in trying to support student sense making of text and graphics on the manner in which acids and bases behaved in solution. Their work showed that for example, using interactive simulations students were able to observe how various concentration ratios of acids and bases affect pH and how such systems function in real time as opposed to how they would when a variety ofконцентрации of acids and bases are represented statically through pictures or in written text. Thus, interactive courseware made relationships between the amount of weight, pH, and concentration on the supply side of and the state of equilibrium more comprehensible for students. This amplified visualization is especially valuable in courses like the ACID-BASE chemistry where a connection between chemical species and concentrations cannot be proved simply in the minds eye. Karsenti et al (2012) also reviewed the effects on incorporation of interactive technologies in chemistry, and found out that these tools enhanced the learning retention of students and their understanding of concepts. Unfortunately, while I was not a student in, say, a traditional high school classroom, the courseware was more interactive than standard lectures, videos or Power-Point presentations, and students have more opportunity to learn actively, which is crucial for retention. The instant feedback of the systems also allowed for immediate error correction and reiteration of the right concepts which led to the development of our students' concrete mental scaffolding with respect to acid base reactions and equilibria.

Furthermore, the feedback given by the material as it is being delivered in the interactive courseware is vital to disprove misconceptions when they are being learned. For example when used penetrating incorrectly for example in applying the concept of pH, the interactive systems can quickly give feedback about ratio of proton concentration. This is actually different from many approaches to teaching in which misconceptions may take longer to be addressed even if they exist in a subsequent lesson or test. The immediate response that interactive courseware offers students benefits students in being able to correct the concept that they got wrong along with another explanation as well as several exercises to do to make new connections in their knowledge. This fast intervention in altering such misconceptions is most effective in chemistry as more often than not basic concepts such as pH, the strength of an acid, and equilibrium are misunderstood and if not corrected early are likely to cost the student good performance in subsequent areas. Accordingly, it is argued that interactive technology can be form of cognitive tool that organises students' learning activity and fosters the construction of more elaborated and accurate mental models. To sum up, it is necessary to state that the application of the interactive courseware can become a promising approach to working out the common improper perceptions in the sphere of acid-base chemistry. Making use of dynamic and possibly graphical representations and feedback, it can facilitate more active and effective learning of chemical concepts than conventional methodologies. In a study of students' conceptual learning, Vosniadou (2007) observed that students who will later show deep understanding have a repertoire of different schemes at their disposal that is different from that of students with misconceptions and low retention rates in chemistry education, interactive learning environments used by Bodemer et al. (2010) show surprising results when students participate in constructing meaning than when meaning is being transferred and finally a research done by K These results support the need for adopting intractive technologies as a tool that assists the teaching process in embellishing whit a more accurate view about acid-base chemistry.

Methodology

This research uses both self-assessment questionnaires and open-end questionnaires to gather data to analyze and assess the usefulness of interactive courseware in reducing misconceptions in the topic of acid-base chemistry. Thus, the synergy of these approaches will allow the research to offer an extensive account of the effects of IL on student knowledge, as well as misconceptions regarding acid-base concepts.

Study Design and Participants

This study took a semester where two groups of students from an introductory university chemistry class were used. The two groups were designed as follows:

1. **Group 1 (Control Group):** The information for this group was presented to the students using conventional methods of passivism of teaching. Combined with the lectures proper, textbook readings and the exercises in problem solving addressed specific aspects of acid-base chemistry: pH, strength of an acid, and buffer solutions and systems. That and the teaching techniques used with this group were conventional,

as the focus was on presentations by the instructors and the mechanics of using textbooks.

2. **Group 2 (Experimental Group):** The students in this particular group were taken through interactive courseware adopted for acid-base chemistry. The courseware comprised of multitude of features inclusive of common features like simulation on pH, strength of acids, buffer systems etc. These simulations enabled the students to ‘‘change the parameters’’ (for example, the concentration of acids and bases) of the systems and to observe corresponding changes in the behavior of these systems in real time. Also, the courseware had quizzes and instant feedback mechanism where once a student did an activity incorrectly, the courseware was able to show the corrected work and explain the errors that the student made. The use of the interactive courseware presupposed active interaction with the content, which is important to support students’ construction of meaningful learning.

Data Collection

To assess the impact of the courseware and its contribution to the reduction of misconceptions and enhancement of student knowledge, quantitative and qualitative data was used in this study.

Quantitative Assessments:

We administered pre-surgeries before the semester started and post-surgeries at the end of the semester to both groups. These were tests intended to determine the degree of students’ knowledge regarding the selected aspects of acids and bases.

- **Pre-assessments:** These were MCQs and SAQs to establish the flow of knowledge of the students about pH, acid strength, buffers, and equilibrium for the reactions of acids and bases.
- **Post-assessments:** In the same manner as the pre-assessments, the post-assessments involved multiple choice items and problems solving items and questions which were given to evaluate the increase in the difficulty level in students’ level of understanding after the implementation of the intervention. Among them, the problem-solving tasks were directly related to students’ practical use of acid-base knowledge including determination of pH in different solutions, estimation of acid strength based on experimental titration data, and analysis of the buffer action in different situations.

The nickel and dime money that was being used to purchase these assessments was a way of comparing the level of understanding between the control and experimental groups. The comparison was useful in evaluating the extent to which the interactive courseware made the learning outcome different from the normal approach to teaching.

Qualitative Data:

However, in order to get a fuller picture of students’ experience with the learning methods, qualitative data was also gathered. This data was collected using cross sectional survey/structured interviews.

- **Surveys:** In this study, after the post-assessment, students in both groups were required to fill in a questionnaire to capture overall experiences. On the survey, they were asked various questions concerning their interaction with the material and the learning information, their impressions as to the efficiency of the courseware in case of learners in Group 2 and the familiarity with the learning methods in both groups. Students were also asked to rate the instructional content regarding its clarity and usefulness, their perceived ability to use the courseware to overcome misconceptions on acid-base concepts, and their self-confidence in the application of the concept to new situations.
- **Interviews:** Among the students in Group 2 which was the experimental group, a purposive sample of participants was interviewed using semi structured interviews. Due to these interviews the researcher was able to further probe the experiences of the students as facilitated by the interactional course ware. These questions concerned students' primary conceptions about acid-base chemistry and how the courseware assistance changed those conceptions, as well as the extent to which the simulations and immediate feedback helped the students eliminate misconceptions. Students were also given questions that asked them about some of the problems they faced when using the courseware, and how the technological tool affected their learning experiences.

Data Analysis

Data from the pre- and post- quizzes were collected from both groups and, using statistical tools, the differences in learning outcome between the two groups were compared. Mean differences between the pre and post test scores of the two groups can be compared using the results of the paired t-tests or analysis of covariance (ANCOVA) to see whether the use of the interactive courseware produces higher levels of understanding than the traditional methods of teaching. The interviews and questionnaires responses were content analyzed to form the themes informing the students' view about the courseware in ECMP 045. Besides the main analysis of the results, interaction, misconception, simplicity, and learning gains themes were discussed to gain deeper insight into the impact of interactive courseware on the students' learning processes.

Results and Discussion

Quantitative Results

Looking at the assessment results before, and after, of the use of the interactive courseware availed gave compelling evidence that the utilization of the latter was instrumental in enhancing students' understanding of the acid-base chemistry concepts. Group 2 who taken the interactive courseware indicated an improvement of 35% of the total test results while on the other hand, theRest: Group 1 indicated a change of 15%. This discrepancy indicates that the use of the interactive courseware a had a positive impact towards improving student understanding.

Particularly notable improvements were observed in several key areas of acid-base chemistry, including:

- **pH and Acid-Base Strength:** The knowledge that Group 2 students seem to have a better grasp of the use of the pH scale, especially in determining strong and weak acids was also evident here. This is a basic concept in acid-base chemistry, but one that is usually a source of confusion to students. The features given involved use of models in which the students can see a representation of how the level of hydrogen ions in a solution is proportional to the pH making it easier to comprehend.
- **Buffer Systems:** Group 2: Another area where the students demonstrated good performance was in issues to do with buffer systems. It showed their enhanced capacity todescribe the mechanism by which buffers help to maintain pH constancy in solution. This concept usually proves to be problematic for the learners, partially because it combines the concept of equilibrium with chemical reaction and the properties of weak acids and their conjugate bases that help them maintain the pH level. The courseware enabled the learners to input variables such as acid/base concentrations and subsequent impacts on pH thus a better perception.
- **Problem Solving in Acid-Base Reactions:** It was also observed that the Group 2 students were better able to solve problems which demand higher order thinking skills in acid-base chemistry such as calculation of pH change during titration. This was a major area of disparity with the students in Group 1 who found it difficult to understand how acids and bases work during titration, and find it difficult to translate theories learnt in class to practical reality. The use of the interactive courseware most probably let the students build confidence when it comes to applying gained knowledge to more complex problems through giving simple step-by-step guidance and other visible feedback.

Qualitative Results

Besides, the results in terms of numerical achievements include changes in the scores on the tests taken by subjects of the Group 2 Students' feedback on their learning process was also acquired. The majority of them preferred the learnability of this style of the course, as the visualization of the concepts which are difficult to comprehend in lectures improves the students' understanding. Most students stressed that the simulations were especially helpful as far as the compliance with general acid-base principles were concerned. Another student said, "I learned from the simulations why the number of a strong acid solution is so low, or in other words, its pH, and how buffer systems regulate the pH." This feedback proves that perceptive games are useful in giving non-tangible content form by enabling learners understand the behavior of acids and bases in solution.

- **Immediate Feedback and Correcting Misconceptions:** The second area identified as crucial to the success of the interactive courseware, and liked by students, was feedback during the quizzes and other activities. A particular student said, "It also enabled me to respond to the effects of quizzes and feedback and correct mistakes as soon as I made them." This is actually one of the strengths of using interactive courseware instead of traditional methods of teaching because students are in a position to correct wrong impressions once they are imprints.
- **Engagement and Motivation:** At large, the participants in Group 2 perceived higher level of relevance of the course content than their counterparts in Group 1. With the courseware being ''open'' and allowing for interactivity, students were encouraged to be more proactive in a way that they shaped how they learn. This is important to put

emphasize that this engagement is important in supporting the learning and continual students attention and interest.

Contrast with Group 1

On the other hand, the students in Group 1 who were taught through conventional lecturing style expressed low participation in the course content.. Although it was good for the part where it is necessary to talk and explain the information, the academic lecture left the students without interaction and illustrations, which would have made it possible for them to grasp the concepts of acid-base chemistry and which elements would make the theoretical and practical sides more connected. Group 1 students were observed to find it challenging to apply the theories in practice; like solving problems involving titration, or predicting the change in pH during titrations. Some of the difficulties that arose in the traditional classroom serting included One of the challenges was that misconceptions could take root because feedback was often delayed, and more to the point, students struggled to identify errors on their part. A number of respondents from Group 1 indicated that they felt the lecturer was either covering too much material in a given class or not enough despite making them understand that they waste a lot of time on topics that are so hard for them. On the other hand, all the students in the Groups 2 were engaged in the development of the interactive courseware in which students could learn at their own pace, thus, the self-directed learning was made possible and it was ensured that students had a chance to solve the problems in the context of the tested concepts until they felt ready for the next move.

Findings

The results should be considered supplementary – quantitative and qualitative – and together they present a strong argument in favour of using interactive courseware to counter misconceptions in the practice of acid-base chemistry. Since the Group 2 benefited from the use of interactive technologies by scoring a 35% improvement compared to the 15% of group 1, the limited study also portrays a significant influence of the technology on learner performances. Moreover, the response from the students in Group 2 reassures the usefulness and an interesting approach of the courseware to embarked in the ideas conversion in the students and instill instant feedback to minimize misconceptions as well as demonstrating the application of such areas in future advanced problems. While, the interactions with Group 1 which were in line with prior educational practices of the author proved quite helpful in minimizing misunderstanding but not quite as successful in helping learners overcome their misconceptions. It is also possible that because traditional lectures are not as engaging as other forms of teaching such as those which include the use of PowerPoint there was less participation and therefore a lower rate of absorbing information in this group. From such results, the author postulates that using interactive courseware in chemist lessons might greatly improve the students' knowledge as well as their problem-solving skills when having to confront such complex material as acid-base chemistry. This paper also demonstrates that interactive courseware can be an effective medium for correcting misconceptions in acid-base chemistry. Making the learning process more interactive and exciting, compared to the traditional lectures and lab activities, interactive courseware enhances students' knowledge of the topic in question, helps dispel misconceptions regarding pH, acid strength, buffer systems, and other issues. The opportunities for real-time assessment of the courseware content and the ability to work through the material let the students successfully visualize the content and hone their problem-solving skills. As a result of the current study, it is recommended that interactive courseware should be included in the teaching and learning process because its incorporation have been found to lead to considerable improvement of students' performance especially in difficult areas of chemistry. Studies can be made in future to investigate the effectiveness of using this kind of interactive courseware in other fields of chemistry and its cumulative impact on the achievements of the learners in a longer term.

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