Reflections from a Computer Simulations Program on Cell Division in Selected Kenyan Secondary Schools

Mwangi Ndirangu, Joel K. Kiboss, and Eric W. Wekesa
Egerton University, Njoro, Kenya
ndirangu2002ke@yahoo.com

Abstract

The application of computer technology in education is a relatively new approach that is trying to justify inclusion in the Kenyan school curriculum. Being abstract, with a dynamic nature that does not manifest itself visibly, the process of cell division has posed difficulties for teachers. Consequently, a computer simulation program, using animated colour graphic images capable of presenting the dynamic nature of the process through a multi-sensory approach, was developed from the existing school biology syllabus and implemented for a period of 4 weeks. Data was collected and analysed to help unravel what was actually happening as the teachers and the students interacted with the computer simulation program and/or instructional materials during cell division lessons. Results indicate that the computer simulation program created a community of meaning makers by enabling learners to aggregate their insights through co-elaboration and self-teaching while interrogating the learning experiences presented by the simulation. Support is provided for the idea that the use of computer simulations can greatly enhance pupils' understanding of cell division concepts.

Introduction

It is becoming increasingly clear that a small group of learners, working collaboratively with a computer in a problem-solving activity, is likely to create an environment that produces greater learning than can be attained by an individual learner working in competition with others (Hausfather, 1996; Kamau, 2003). This is because computer-mediated collaborative learning creates a stimulating environment that encourages student involvement, as well as learning from one another. Philip (1984) similarly reports that active participation and healthy reciprocal relationships can be bolstered when learners are allowed some freedom to interact with one another and to work cooperatively. In addition, the capability of the computer to personalise learning can lead to new experiences that often increase motivation and attention among learners (Wekesa, 2003). The underlying assumption for the incorporation of computers in science instruction is that the use of the computer might transform the teaching-learning activity/process. This could occur by changing the usual teacher-dominated activity of presenting factual knowledge into an interactive learner-centred process that nurtures confidence, initiative, and the enhancement of cognitive and affective behaviour (Relan, 1992).

Many different aspects of school science in Kenya tend to make understanding difficult for pupils and inhibit their learning (Kenya Institute of Education [KIE], 1992; Wekesa, 2003). For instance, the topic of cell division in school biology has consistently been rated the most difficult to learn by pupils and the most difficult to teach by teachers (KIE, 1992; Wekesa, 2003). Besides, a considerable number of learners have been found to hold an inadequate understanding of cell theory and associated underlying concepts such as mitosis, meiosis, chromosomes, and chromatids, even after the conclusion of the instructional process (Wekesa, 2003). Although the current recommended practicals for learning cell theory in the biology syllabus include the use of squashed young onion root tips, charts, or electron micrographs (KIE, 1992), these materials do not reflect the dynamic nature of the process because they lack movement and colour.

Presenting science lessons through computer-based learning (CBL) is a recent innovation that may be effective in improving the cognitive and affective skills necessary for learning and doing science. Although laboratory work is important in influencing cognitive and affective student outcomes, little research has been done to understand teacher/student involvement and classroom interaction behaviours that involve the use of the computer in science instruction (Tanui, 2003). It is against this background that this research was undertaken, aimed at understanding students' reflections regarding their actions and interactions during biology classes.

Theoretical Framework

The theory guiding this study is the social learning theory, developed by Bandura (1982), that has been widely used to study students' actions and involvement in classroom activities (Relan, 1992). In his research with recovering heart attack victims, Bandura discovered that patients' belief in their ability to overcome phobias about exercise affected their performance. He then theorized that an individual's belief, based on previous experience, is closely linked to behaviour with respect to phobias. Behaviour according to this theory is based on two factors: (i) the generalized expectancy about action-outcome based upon life experiences and (ii) the development of the specific belief concerning ones own coping abilities.

According to this theory, behaviour is enacted when persons not only expect certain behaviours to produce desirable outcomes, but also when they believe in their own ability to perform the behaviours. In terms of teaching and learning, the teacher believes in his or her ability to teach and to have students learn. Following this theoretical framework, classroom behaviours do reflect both the dimensions of a teacher's belief about the teaching and learning outcomes he or she believes to be possible through classroom practice, or the teacher's belief that students' learning can be influenced by instruction. Therefore, teacher/student descriptions of classroom interactions or behaviours, although difficult to define conceptually, form the framework of effective learning in science (Robinson, 1994).

In this regard, the research discussed above forms a framework of factors that relate to reflections of classroom practices in computer-based biology lessons on cell theory. This is because teacher-student, student-teacher, student-machine, machine-student, and student-student interactions during the lessons are variables that do influence students' cognitive and affective learning.

Methodology

*Research design***.** Most of the studies about the effects of new technology on learning use self-reported quantitative data, with very little, or no, data coming from direct observations of, and/or interviews with, learners (Ayersman, 1996). This qualitative study used a non-equivalent control group design, but with two experimental groups.

One intact, Form 3 (16-year-olds) class, from each of three schools that had computers and could be easily accessed from the Nakuru-Nyahururu and Njoro-Mau Narok roads, were involved. The classes were randomly labelled Experimental I (Class E_1), Control (Class C), and Experimental II (Class E_2). Each class had 22 boys and 18 girls, giving a total of 120 student participants. While one of the experimental classes was taught by a female, the other two teachers were male.

The study had two aspects. The first was systematic, classroom-focused observations of the verbal and non-verbal classroom interactions that occurred during the instructional processes, providing descriptive data of the common patterns, variations, and forms of social behaviours that occurred in the classrooms as the teachers and students interacted with the instructional materials. These observations were made by the researcher and two research assistants, with one person visiting each of the three classes, and recorded in shorthand on an observation schedule. A total of eight, 40-minute lessons were observed in each school.

The second aspect of the study comprised interviews, carried out immediately after the end of the experimental period, aimed at unravelling the meanings that the teachers and students attached to their classroom interactions and/or experiences with the instructional material, as recommended by Tanui (2003). The interviews involved the two teachers of experimental groups, who were interviewed individually, and 20 students, who were randomly selected from one experimental group only, interviewed as a group. A Teacher Interview Guide (TIG) and Student Interview Guide (SIG) were used to capture episodes to illustrate the perceptions of both teachers and students about the use of the CBI module, and the data were faithfully transcribed in shorthand.

To ensure the observation and interview data were complete and accurate, the researcher (or assistant) went over a clearly-written record of the captured data with the respondents, and errors and misconceptions were clarified. The data was then coded and categorised.

The lesson versions. While Class C was exposed to the regular, or traditional, teacher-centred pedagogy, Classes E_1 and E_2 used the CBL mode. In the former, the teacher was in total control of the instructional process, which involved utilising the usual teaching style as suggested by the Kenya Institute of Education (KIE) syllabus. In the latter, the teacher played the role of a facilitator and was required to organise and supervise the learning activities during the computer lessons. The lessons were taught for a period of 4 weeks.

The domain. This study involved the sub-domain of cell theory in the biology syllabus for secondary schools in Kenya. The primary educational goal of this course is to teach students the location and orientation of chromosomes and chromosomal movement during mitosis and meiosis. Normally, squashed young onion root tips, charts, or electron micrographs are used, materials that lack a dynamic process (KIE, 1992). The CBL simulation module comprised animated colour graphic images highlighting the dynamic nature of cell division. This is important for stressing that the process of cell division does not occur in discrete stages as depicted in textbooks. The lessons contained instructions on the following five sub-topics that form the general stages of cell division: interphase, prophase, metaphase, anaphase, and telophase.

Data Analysis and Discussion

The qualitative descriptions presented here are based on the observed patterns and variations characteristic of the teacher/student interactions that transpired during the learning processes, as well as the interviews. Data from both the experimental and control situations are compared in order to help understand the usefulness of CBL programs for teaching this abstract, complex, and difficult topic.

Role of collaborative techniques in the promotion of a healthy classroom climate. The following excerpt is indicative of how the students in a CBL simulation class attempted to work together during the learning tasks:

> *Njeri*: Look! Let’s go back a bit.
> *John*: Where?
> *Njeri*: The previous stage. I didn’t really get it how the chromosomes are changing colour.
> *Juma*: Those are not chromosomes changing colour, it’s called genetic crossover.

> *Teacher* (moves closer to the group): Actually, Njeri is right. It is the chromosomes changing colour. But what does the manual tell us about colour?
> *Tom*: Colour has been used to highlight the aspect of genetic crossover.
> *Teacher*: Good, Tom. The colour change in chromosomes tells us, or shows us, how genetic crossover occurs to bring about diversity in species. (Observation Notes, School E_1)

This episode depicts a picture of how students and their teacher engaged collaboratively in a computer-simulated learning task. In effect, they were willing to listen and to allow each other the opportunity to participate in the learning task. It also enabled learners to take initiative, interact, and express alternative ideas (Pearson & Lewin, 2005). This is, of course, a confirmation of the findings of earlier studies that the use of CBL simulation engenders greater social interactions that may lead to a sense of self-actualisation among the participants (Philip, 1984). Peer tutoring is also very evident here, as the learners try to negotiate meaning through co-elaboration (Vygotsky, 1978). This develops a sense of ownership of the knowledge thus acquired, as opposed to the alienation that would likely result from teacher-centred teaching.

This reconciliation of the different views of various people involves the social mediation of individual knowledge throwing up contrasting views that challenge individual perceptions. This confirms earlier findings that learning tasks that take place through social interaction help learners construct knowledge together, and that information and skills are best gained from group learning situations where learners are able to internalise skills through discussion, arguments as they negotiate new positions, or meanings (Driscoll, 1994; Tanui, 2003).

Moreover, the use of the CBL simulations module exerted influence not only on the learners, but also on their teachers as well. For example, the following excerpt demonstrates how the CBL simulations module was perceived as having helped in teaching:

> *Teacher*: I think I have also learnt a lot. You know, I've never been successful in preparing the microscope slide on cell division. When you are through with us, I will bring in my Form 4s to revise this topic with them using this method . . . . in fact, this settles one of my greatest problems. This topic is so short, yet it takes me a long time to cover because I can't just draw. (Interview, School E_2)

An appreciation of the benefits of using technology in the classroom is evident here, because the teacher was able to realize personal gains. This is evident by the fact that the teacher wishes to also revise the topic with Form 4 classes, as he feels the topic was not well taught to them using the traditional method. He also admits having been helped to overcome his inability, to draw diagrams to illustrate the process, through the use of the CBL simulations module. The expression "learnt a lot" seems to emanate from the realization of the potential benefits of the dynamic attributes of the CBL simulation modules that are lacking in conventional laboratory practicals on cell division (Allessi & Trollip, 1991; Wekesa, 2003).

> *Teacher*: Well this is a new experience that is very promising. I have been able to do things that I cannot do in the regular class. This is a program that I would encourage it to continue thereafter. The way the students have been able to work in small groups and manage their own learning is quite encouraging and helpful in covering this short course that often takes long to teach because of the difficulty of getting the right instructional materials. (Interview, School E_1)

From the teacher's admission that the program enabled learners to work together in small groups and manage their own learning, this excerpt shows that the teacher's use of the CBL simulation module was indeed beneficial. In fact, the teacher admits that the use of the program is something he would encourage even after the termination of the research project. This is perhaps a strong indication that teachers are willing to embrace new methods should they realize their effectiveness in improving students' learning in areas that lack adequate instructional resources.

Biology lessons in the regular classes, unlike in the experimental classes, were marred by problems emanating from the inability of learners to cut the young onion root tips to the sizes required. The following excerpt, captured in a control class during a biology laboratory experiment, vividly illustrates the complexity of the problems that make the teaching of cell division difficult:

> *Teacher*: Because of the scarcity of the equipment [microscopes], we shall be working in groups of 4 per microscope. Using a young onion root tip, we will make thin sections and see if we can observe chromosomes at various stages and orientation of cell division [students follow steps given on the chalkboard . . . get busy with the learning task].
> *Kim*: Hey! That is not thin enough.
> *James*: OK, then you do it [James takes the new razor blade to make a thin section].
> *Teacher*: Is any group ready? [Seeing a raised hand, teacher moves to a group at the back of the classroom] Let us see what you have here.
> *Teacher*: [Observes what is in the microscope] Not quite … this section is not thin enough.
> Teacher: [Addressing the whole class] Make sure you do not crash the root tip, or else you won't see anything.
> *Alfayo*: Sir! How can one make a section any thinner than this?
> *Kim*: I can't see anything in our microscope. Tom, can you see anything?
> *Tom*: [Moves over to the microscope to observe] No, I can't see anything either.
> *Teacher*: [Moves to an adjacent group to observe the section in their microscope] These things [sections] are not visible. (Observation Notes, School C)

This observation was made during a cell division laboratory session where the students were learning using the regular method. It reveals the students' futile effort to obtain a sufficiently thin section to assist them observe chromosomes at various stages, and orientation, of cell division. It provides an indication of the difficulties that learners often experience due to a lack of apparatus and/or material to assist them learn complex processes that do not readily manifest themselves to the naked eye. Although the use of real objects is invaluable in the learning process, not all are effective in enhancing an understanding of complex concepts that require simplification in order to be appreciated. In effect, this observation supports Wekesa's (2003) assertion that students often find the topic of cell division difficult to learn, thus making its teaching difficult.

Furthermore, the episode is evidence for how tedious and frustrating the learning of this topic can be for most teachers and students in traditional classrooms. The CBL classes were free from such problems because the complexity of observing chromosomes at various stages and orientation of cell division was simplified by the use of the CBL simulations. The learners in the CBL classes seem to have gained better insights into the process of cell division than their counterparts in the control classes because the CBL simulations simplified the learning process. However, this does not mean that these learners did not experience problems. Their problems, though, were more concerned with the operation of the computer.

Human-machine interactions and personal concerns triggered by the use of CBL in science learning. The participating teachers were interviewed to determine their perspectives regarding the use of CBL simulations in teaching cell division compared with their regular teaching methods. The following excerpt reflects the gradual paradigm shift on the part of the teacher:

> *Researcher*: At the start, the class seemed noisy and you were concerned. What do you say about that now?
> *Teacher*: Well, I got a bit worried that I could loose control of the class, but since you emphasized that the students should discuss and work in groups, I thought it was fine. But . . . well the anxiety went down almost immediately as the students got immersed into the computer. (Interview, School E_1)

This excerpt shows some initial sense of nervousness, on the part of the teacher, about implementation of the CBL simulation module. This seems to stem from her fear of the loss of authority or control of the classroom discourse. But on realizing how the students engaged in the learning without much trouble, her anxiety went down. This signifies the change, or paradigm shift, that teachers often experience which leads them to embrace innovations (Papastergiou, 2005). This becomes even more apparent in the next excerpt, which shows a teacher's willingness to embrace CBL in her class after recognising the potential benefits of the new technology.

> *Researcher*: What did you think about your role then when you began teaching using the CBL?
> *Teacher*: Well, this is a totally new experience for me, but I am worried it might not continue thereafter. But I would say letting students manage their own learning in small groups to learn around the computer has been very interesting. Earlier, I was worried it could not work out.
> *Researcher*: What do you say now?
> *Teacher*: Great! It has enabled me to move around . . . to guide students here and there and answer their questions. I would definitely use it again in future should the program continue. (Interview, School E_2)

From the foregoing, it becomes clear that the use of CBL simulation programs can exert a positive influence on not only students' learning in science classrooms, but also on teachers' teaching style. This is in accord with earlier findings in the area of CBL studies (Lazarowitz & Huppert, 1992; Wekesa, 2003; Wenglinsky, 1998).

Conclusion

Science teaching and learning is intrinsically difficult, given that it requires concentration, self-regulated behaviours, persistence, cognitive effort, and a positive, mastery-oriented outlook. As such, the role of the teacher, instructional materials, and learner participation in influencing and/or improving achievement is critical (Zietsman & Naidoo, 1997). An understanding of the impact of innovations, in combination with teachers' practice, is therefore necessary. CBL provided a collaborative environment which enhanced social interaction and self-teaching. For this to happen, though, the teacher must induct learners to the appropriate standards of conduct required to bring about the achievement of good things (learning) internal to the practice (teaching). For this reason, it is invaluable to reflect upon practice in order to unearth the virtues of an innovation.

The episodes presented have demonstrated the value of using CBL simulation programs for the teaching and learning of what otherwise can be a complex, difficult topic. What transpired in the CBL classes is evidence of teachers' success stories in using an innovation to overcome their previous inability to help learners understand the complex process of genetic crossover. The findings imply that CBL programs may be a solution to other hidden problems, such as a teacher's weakness in drawing diagrams and the limited time available to teach the topic in the school timetable.

What was captured in the regular classes that did not use the CBL simulations echoes the problems and limitations associated with the use of onion root tips and microscopes to teach cell theory. Teachers' efforts to help learners understand the theory of cell division was often marred by an inability to cut sufficiently thin sections of an onion root tip and/or crushing it, and the success stories observed while using the CBL simulations program can also help solve problems like this. This is in line with the literature regarding the use of CBL to provide meaningful, cognitively supportive instruction geared towards the improvement of performance (Philip, 1984). Moreover, when CBL programs aim at captivating the attention of learners, they also promote a feeling and expectation of success. In other words, they enhance self-efficacy and foster achievement, as well as foster positive effects through social interactions that promote the effective communication of scientific content and procedures, thereby enhancing science learning and doing by students and teachers (Tiffin, 1994; Tobin, 1996).

An important area that is not addressed in this study is the use of language in classroom discourse, probably because English is the accepted, standard medium used by both teachers and students in Kenyan schools. Students' classroom discourse is therefore seldom in either their home language or the national language, Kiswahili, and this creates a dilemma for both teachers and students, because the sole use of a second, or even a third, language may interfere with students' understanding. There is a need for closer attention to be given to understanding the use of language in Kenyan science classrooms.

For a majority of the learners who participated in this study, this was the first time they had used CBL in the learning process. It is unclear whether the same level of interest and attention would be maintained once the novelty wore off. At the same time, without the teachers presence in the classroom, learners are likely to be distracted from on-task activities.

References

Allessi, S. M., & Trollip, S. R. (1991). *Computer based instruction: Methods and development*. New Jersey: Englewood Cliffs.

Ayersman, D. J. (1996). Reviewing the research on the hypermedia-based learning. *Journal of Research on Computing in Education*, *28*(4), 500-525.

Bandura, A. (1982). Towards a unifying theory of behavioural change. *Psychological Review*, *84*(2), 191-215.

Driscoll, M. P. (1994). *Psychology of learning for instruction*. Needham, MA: Allyn & Bacon.

Hausfather, S. J. (1996). Vygotsky and schooling: Creating a social contest for learning. *Action in Teacher Education*, *18*, 1-10.

Kamau, L. N. (2003). *ICT in education: An investigation of the possibility of its implementation into the Kenyan education system*. Unpublished master's thesis, University of Manchester, UK.

Kenya Institute of Education (KIE). (1992). *Ministry of education, secondary education syllabus, volume seven*. Nairobi: Kenya Literature Bureau.

Lazarowitz, R., & Huppert, J. (1992). Science process skills of 10th –grade biology students in a computer-assisted learning setting. *Journal of Research on Computing in Education*, *25*, 366-382.

Papastergiou, M. (2005). Learninig to design and implement educational web sites within pre-service training: A project-based learning environment and impact on student teachers. *Learning, Media and Technology*, *30*(3), 263-279.

Pearson, M., & Lewin, C. (2005). Online education and learner autonomy. *Learning, Media and Technology*, *30*(3), 259-261.

Philip, R. (1984). The future of the micro-computer as a classroom teaching aid. *Computer Education*, *8*, 173 – 177.

Relan, A. (1992). *Motivational strategies in computer-based instruction: Some lessons from theories and models of motivation*. In Proceedings of Selected Research & Development Presentations at the Convention of the

Association for Educational Communications and Technology. (ERIC Document Reproduction Service No. ED 348 017)

Robinson, H. A. (1994). *The ethnography of empowerment: The transformative power of classroom interaction*. Bristol, PA: The Palmer Press.

Tanui, E. K. (2003). *Relative effects of a computer-based instruction in accounting on students' achievement: Perception of Classroom Environment and Motivation in Secondary Schools in Kenya*. Unpublished doctoral dissertation, Egerton University, Njoro, Kenya.

Tiffin, S. (1994). *The key to profit: A practical guide to managing science and technology*. Ottawa: IDRC.

Tobin, K. (1996). *Cultural perspectives on teaching and learning of science*. Paper presented at the Symposium of Traditional Culture, Science, and Technology and Development: Toward a New Literacy of Science and Technology conducted by the Tokyo Institute of Technology, Tokyo.

Vygotsky, L. S. (1978). *Mind and society: The development of higher mental processes*. Cambridge, MA: Harvard University Press.

Wekesa, E. (2003). *Effects of a computer-based instruction module on students' achievement, perception of the classroom environment and attitude towards school biology in Nakuru District, Kenya*. Unpublished masters thesis, Egerton University, Njoro, Kenya.

Wenglinsky, H. (1998). *Does it compute? The relationship between educational technology and student achievement in mathematics*. Princeton, NJ: Educational Testing Service.

Zietsman, A., & Naidoo, S. (1997). *Girls' understanding of concepts of thermal properties of matter* (Abridged Research Report No. 22). Nairobi: Academy Science.