The South African Institute for Computer Scientists and Information Technologists

ANNUAL RESEARCH AND DEVELOPMENT SYMPOSIUM

23-24 NOVEMBER 1998
CAPE TOWN
Van Riebeeck hotel in Gordons Bay

Hosted by the University of Cape Town in association with the CSSA,
Potchefstroom University for CHE and
The University of Natal

PROCEEDINGS

EDITED BY
D. PETKOV AND L. VENTER

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FOREWORD

The South African Institute for Computer Scientists and Information Technologists (SAICSIT) promotes the cooperation of academics and industry in the area of research and development in Computer Science, Information Systems and Technology and Software Engineering. The culmination of its activities throughout the year is the annual research symposium. This book is a collection of papers presented at the 1998 such event taking place on the 23rd and 24th of November in Gordons Bay, Cape Town. The Conference is hosted by the Department of Information Systems, University of Cape Town in cooperation with the Department of Computer Science, Potchefstroom University for CHE and and Department of Computer Science and Information Systems of the University of Natal, Pietermaritzburg.

There are a total of 46 papers. The speakers represent practitioners and academics from all the major Universities and Technikons in the country. The number of industry based authors has increased compared to previous years.

We would like to express our gratitude to the referees and the paper contributors for their hard work on the papers included in this volume. The Organising and Programme Committees would like to thank the keynote speaker, Prof M.C.Jackson, Dean, University of Lincolshire and Humberside, United Kingdom, President of the International Federation for Systems Research as well as the Computer Society of South Africa and The University of Cape Town for the cooperation as well as the management and staff of the Potchefstroom University for CHE and the University of Natal for their support and for making this event a success.

Giel Hattingh, Paul Licker, Lucas Venter and Don Petkov

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HANDLING DIVERSITY IN INFORMATION SYSTEMS AND COMPUTER SCIENCE STUDENTS: A SOCIAL CONSTRUCTIVIST PERSPECTIVE

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Abstract

This paper describes the social constructivist theory of learning and how it can be applied to handle the problems of diversity in Information Systems and Computer Science classes. Examples are given on methods that can be used to promote learning in the classroom, for IS problems and for programming.

Introduction

The skills and dispositions that are needed by people in order to achieve success include "the capacity for critical thinking and complex problem solving, respect for people different from oneself, principled ethical behaviour, lifelong learning and effective interpersonal interaction and teamwork." [Gardiner, 1994, p.1]. The question we must ask ourselves is if we are developing these skills in our students.

The diverse student populations coming into tertiary education are seen as a problem in South Africa. [Goduka, 1996a; Starfield, 1996]. Students from different backgrounds, with very divergent educational standards, come into tertiary education and are all given the same work and expected to understand it in the same way. This problem is especially true in the Information Technology field where some students must be shown how to turn their computer on, while others have been using computers from an early age.

Some of the students have English as their second or even third language and have a problem understanding English making it even more difficult for them to understand the concepts and how to apply them. McLaughlin [1996] reports a similar problem in Papua New Guinea among second language English students. Because of their poor English, the students learn without understanding. Teachers can exacerbate the problem. An example he gives to illustrate this is the following [McLaughlin, 1996, p112]:

"Teacher:	A gibob is a zingut and is used for willoting things together. Alfred, What is a gibob?
Alfred:	Sir, a gibob is a zingut and it is used for willoting things together.
Teacher:	Excellent answer."

This type of teaching happens from an early age and makes it very difficult for students to think critically. Students are encouraged to parrot back what they have learnt without necessarily understanding what they are supposed to understand.

Students are taught by rote learning and learning from the textbook only. They find it difficult to work without a textbook or to engage in free enquiry and discussion [Ruth, 1996]. Many of the students from disadvantaged backgrounds, find it difficult to ask questions in class or to participate in classroom discussions especially when the whole class is present. Many are afraid that their language skills are not adequate or that the other students in the class may see their questions as naïve.

Many of the students coming into the tertiary institutions in South Africa are inadequately prepared for the new role that they must play. Many are first generation students whose parents have high expectations of them thus putting them under a lot of pressure. Apartheid education was designed to promote an authoritarian way of teaching and students are taught not to question [Ruth, 1996]. Current teachers, brought up with this method of teaching, continue to teach in this way. This authoritarian school system means that students are afraid, especially at first year level, to interact with their lecturers [Winschiers, 1997].

Students' attitudes can also be a problem. Students see it as the staff members' role to provide them with answers to questions and to make sure that they pass [Sanders, 1992]. They are thus reluctant to do assignments that require them to find information or solve problems that have not previously been done by their lecturers.

While ill-prepared students are a problem, the diversity of students should not be seen as a problem but rather as an opportunity according to Goduka[1996b]. She states that the problem occurs when we try to change our diverse student population to all be the same. As Hamm and Adams [1992, p.9] state "differences should not be confused with defects." Diversity should be integrated into the curriculum and learning environments that allow each student to be different should be developed.

Constructivism

Constructivism is a theory that helps us to understand how people learn by constructing knowledge. Social constructivism studies the process of collaborative construction of knowledge that occurs when groups of people interact [Stacey, 1998]. The process of constructing knowledge, dealing with misconceptions and using social interaction to promote learning will be described below.

Constructing knowledge

Constructivism emphasises the active role of learners in constructing their own knowledge [Dufresne et al., 1996]. Different students will learn in different ways. They use their existing knowledge to make sense of any new knowledge presented to them. Although we teach all our students in a class the same way they may all come away with a different understanding of what has been presented. The knowledge that the student has may affect the student's ability to learn new knowledge especially if the new knowledge conflicts with previous knowledge [Mestre, 1994].

The content, the context, the learner's activity, the prior knowledge of the learner and the goals of the learner will all determine what the person understands [Savery & Duffy, 1995].

As learners can only interpret information in the light of their own experiences, what and how that interpretation takes place will be, to a certain extent, individualistic [Jonassen, 1991]. Constructivism impresses on us the need to understand more about the individual and how they learn [Gruender, 1996]. The implication of this is that learners need to actively engage in the construction of their own knowledge and that we need to test that this construction is taking place correctly. Learners also need the time to reflect on their own understanding of problems [Savery & Duffy, 1995].

Some constructivists take this idea of constructing knowledge to the extreme and insist that, as knowledge is local to an individual, it cannot be taught or found in books and other materials. They claim that there can be no shared reality or shared understanding of language [Magadla, 1995]. This has been challenged and does not seem to be the current view of most education researchers [Gruender, 1996; Reigeluth, 1991]. Reigeluth [1991] argues that there are many types of skills that need to be learnt and that conventional teaching methods are probably fine for some of them.

The Cognitive Flexibility Theory, an extension to the constructivist theory, takes this construction of knowledge a step further. Spiro, Feltovich, Jacobson & Coulson [1991] claim that in ill-structured domains the student cannot just use their pre-existing knowledge, but must be flexible about using that knowledge. The prior knowledge itself must be reconstructed. Instead of retrieving from memory an item that tells the person how to act, the person needs to bring together knowledge from a variety of memories and adjust these to suit the new problem to be solved.

Misconceptions

As learners use their previously held beliefs and knowledge to understand any new concepts, this can also mean that they use their previously held incorrect knowledge and misunderstand what is being taught. This is especially true in the sciences where many misconceptions or alternative conceptions have been identified [Dufresne et al., 1996]. Even when two people have a discussion and think they understand each other, there is the chance that they do not perceive the same reality [Duffy & Jonassen, 1991].

When learning science, for example, students often have a "private understanding" or "naïve model" of how things work [Perkins, 1991]. The concepts of speed, velocity, acceleration and force, for example, are concepts that have different meanings in everyday life to the meanings that scientists have for them. An example, used by Mestre [1994], is the concept of acceleration. Ask someone who has not taken physics as a subject before, to describe how acceleration was experienced when throwing a ball in the air and letting it fall. The person would probably state that the ball would have a large acceleration just after it was released and the acceleration would diminish as the ball goes up. At the top it would be zero and then it would increase as the fall fell. The misconception is that acceleration is the same as speed.

Social interaction

Although learners construct their own knowledge, their interaction with others will also influence their learning. Learning needs to have social interaction so that the learner can explain their own understanding and receive feedback from others. This process forces the learner to clarify their own understanding when explaining it to others. Learning in groups often involves gaining group consensus which means that learners must convince one another of the right approach or learn from each other that their approach has flaws [Stacey, 1998]. Cognition has a social nature and the community that we live in will have an influence on the knowledge that is constructed [Dufresne et al., 1996].

We must encourage students, not only to be problem solvers, but also to make sure that others accept their solutions. They should be able to have an argument with others and defend their ideas while being flexible enough to change their ideas if others can prove their ideas to be better. Collaborative groups are important because they allow students to test their understanding and examine the understanding of others. This in turn will allow them to get a deeper understanding of what they are studying [Savery & Duffy, 1995].

Implications for tertiary education in South Africa

The main implication of the constructivist view of learning for teaching is that teaching should be aimed at helping the students create within themselves the constructs they need, how to learn these constructs and how to explain these to others [Gruender, 1996]. We should also enable the student to learn by connecting the new knowledge to their previous experience and knowledge.

The second implication is that we must acknowledge that not all students are the same and we should structure our curricula to incorporate those differences. We must make sure that we determine what each student has learnt and not expect all to learn in the same way.

Constructivism does not tell one how to teach. It does, however imply that students should be exposed to learning opportunities that enable them to [Brooks & Brooks, 1993; Dufresne et al, 1994; Swan & Hughes, 1993; Jonassen, 1991; Savery & Duffy, 1995]:

- examine their own ideas;
- participate actively in their learning;
- change from remembering and reciting information to learning independently using critical thinking skills;
- engage in writing, talking, describing, explaining and reflecting;
- realise the purpose of the learning activity;
- develop ownership of the problem or task;
- work in an environment that closely matches the one that they will need to function in later;
- determine the extent to which new experiences make sense in the light of their own ideas;
- consider alternative explanations ; and
- evaluate the usefulness of a number of perspectives.

This means that lecturing is likely to be less effective than the more active approaches to learning. Methods of teaching that encourage students to think about what they are doing and make strong connections between their new knowledge and existing knowledge are likely to increase the amount of learning that takes place [Selden & Selden, 1996]. Learning should be an active process, which means that the learner must attend to or actively engage in the process. The teacher should facilitate this process

[Anderson, Reder & Simon, 1996]. Students can be emotionally attached to their own ideas (even if they are misconceptions) and will not give them up easily. It can, therefore, take some effort to challenge students into revising their ideas.

The Cognitive Flexibility Theory, which is an adaptation of the constructive theory, adds another factor to the way that we should teach. Spiro et al. [1991] claim that when teaching and learning the same material should be covered at different times, for different purposes and from different conceptual perspectives. This will enable students to understand the material and be able to use it in different contexts and integrate the material with other material to solve complex problems.

In conventional authoritarian instruction, learners often learn to answer questions and bury any conflict with their own preconceived ideas. They answer questions the way that the teacher wants them to but are unable to answer qualitative questions where understanding is needed as they still cling to their "naïve model" [Perkins, 1991]. The constructivist theory asks us to confront the learner with his/her misconceptions so that they can realise that their preconceived ideas are incorrect. This can be very difficult for students.

Implementation of constructivism in IS and CS curricula

The ultimate goal of instruction should be to "help the student structure his/her knowledge so that it can be used for analysis, discussion and problem solving" [Leonard, Gerace, Dufresne & Mestre, 1994].

One of the very important lessons to be learnt from constructivism is that active student involvement is necessary for learning. While lecturing, we fail to determine if the misconceptions that students have, are interfering with their ability to understand the current work being taught. Students should be challenged with the gaps, flaws or discrepancies in their existing knowledge in order to help them change the way that they perceive and learn something new [Gravett, 1995].

The problem is often the curricula and the way that the curricula are taught [Starfield, 1996]. Staff members are unable to cope with diverse student bodies. There is often a mismatch between the teacher's understanding of the task and that of the student and both find it difficult to bridge this gap. The teacher should not only teach the facts and concepts in the curriculum, but they should also help the students to learn how to listen, speak, read and write in order to get a deeper understanding of the curriculum. They should also pay attention to helping the student transfer the knowledge into real life or between the different subjects.

This section gives some guidelines and examples as to how to prepare one's students for this type of work and how one can incorporate these principles into one's own teaching.

Preparation for groupwork

The constructivist way of thinking offers a strong reason for allowing students to discuss options and work in groups. Groupwork enables students, through discussion, to bring different perspectives to the designing of solutions and should help students to consider more options and issues. The students can be encouraged to exchange views with others and become more aware of alternative solutions [Parsons & Drew, 1996; Johnson, Johnson & Smith, 1991]. This also makes it more interesting for the students.

Groupwork also helps to develop the student's interpersonal skills and qualities and makes them better team members. This is becoming more and more important in the workplace [Meyer, 1993]. Meyer claims that groupwork promotes a "humane and democratic attitude" on the part of students. The students learn to work together and can both give and receive help. The individual students should experience less anxiety within the group than if they are required to work on their own. They should develop their interpersonal skills and learn to trust other people [Johnson, Johnson & Smith, 1994]. The advantages of using groupwork and the need for groupwork in industry should be pointed out to the students.

Students must, however, be taught to work effectively in groups. They need to be given instruction and be able to practise skills like:

- being authoritative rather than aggressive;
- teamwork skills;

- getting consensus within the group;
- giving constructive criticism; and
- accepting criticism.

Applying constructivist techniques in programming

As programming lecturers, we may be patting ourselves on the back at this stage as we are sure that in our subject, we do offer the student time to apply their knowledge and to be confronted with their misconceptions. Most, if not all, programming curricula offer the students opportunities to practise their programming skills on the computer, to find their syntax and logic mistakes and correct their misconceptions.

Experiences with students have shown that fundamental misconceptions still exist despite this, however. Students programs (and even those of programmers in production environments) still have bugs or are not easily maintained. I have even had students in first year reproduce a program that was given previously in class, word for word, when the question asked was not relevant to that program.

One method that could be effective, given a constructivist approach, is to give some examples of programs written by students from previous years or students in their class and have them determine which is the best. Each program or system could be evaluated for the different factors that are used when marking the program, like for example, the user interface, the flexibility or maintainability of the program.

Another method of letting them confront their own misconceptions as well as allowing the students to experience working in an environment that is closer to that of the real world is to allow students to do walkthroughs of each others programs. This would help them to see alternative solutions and to adjust their thinking if it is flawed.

As mentioned before, students should be given more groupwork in their programming and systems development projects. The problems that can be handled by a group can be done in greater depth and be more complex than the problems solved by individuals [Parsons & Drew, 1996]. The group will generally be able to get a better solution or design than an individual.

Certain problems do exist in using groupwork for programming subjects, however, and these problems are often associated with the grades given being proportional to the amount of work done by the different students in the group.

One method of handling this problem is to allow the students to use a form of "buddy rating system". McNeil [1997] describes how this has been done at Rhodes University where the students were asked to rate each others contribution to a project they were asked to hand in.

Some of the techniques of co-operative learning can help us to organise our groupwork in such a way that the problems of students getting grades that they have not earned are reduced. Co-operative learning encourages interdependence within the group together with individual accountability. The tasks can be set in such a way that the students can be graded on their individual parts of the task as well as on their group effort. Students can be asked to help one another and get, not only an individual grade, but also a grade based how well the other people in the group faired [Johnson, Johnson & Smith, 1991].

When students collaborate they share the process of constructing knowledge. This enables the students to think about and elaborate on their own ideas and those of others in the group. The student's fellow group members become collaborators rather than competitors in the learning situation [Strommen, 1992].

Constructivism in the lecture room

We should foster active learning in the classroom. One simple technique that has been quite effective for me is to use the "pause". Allow students time to discuss what has gone before in the class with their fellow classmates. Set them tasks to talk to their neighbour/s about the preceding class. Examples of questions might be: What was the most difficult thing for you to understand? What do you think was most important or least important? Have the students discuss what they did not understand with each other and try to answer each other's questions. Give time after this "pause" to discuss with the students any problems that they could not answer. Students who are afraid to ask questions because they think their questions were stupid or that only they had a problem will now ask their questions if they find that their neighbours have the same difficulty.

We should build diversity into our curricula. So often, the examples we use are relevant to only a certain group of students. We should try to diversify our case studies and problems so that they reflect the population of students and allow the different students to be "experts". Systems that we ask our students to develop are often those that we are most familiar with, for example, an ordering system or a system to keep track of students subjects and marks.

Students can be divided into heterogeneous groups to work on various systems analysis and design projects. We should diversify the systems, using systems like the clinic in a disadvantaged area of our city or the local health club. These systems would allow diverse students to be seen as the experts in a particular area as well as for them to experience what it is like to be someone who is not an expert in an area. The more disadvantaged student would have attended the local clinic and could be used as the "user" who explains to the other students what is needed for that system. The student models the system with his/her fellow students.

Another aspect of constructivism that we should try to apply is to allow the students to see things from different perspectives. This could be done by critiquing each other's work and that of the lecturer. It could also be done by using different modelling techniques on the same system, for example, using an object-oriented approach or a relational database approach and comparing the results.

Encouraging active learning during class time take effort from the lecturer but is one way of encouraging students to make sure that they understand what has been taught and checking that understanding.

One of the problems that are experienced by lecturers in allowing more student interaction is that there is no time for this to happen. The curricula are so full that there is no time to promote discussion and group work in the classroom. Dufesne et al. [1994] and Gravett [1995] suggest overcoming this problem by swopping the way that we teach around. Instead of us giving students the facts and then letting them work on problems at home, we should let the students study the facts on their own and use their lecture time to allow them to work in groups, discuss and think about problems in the area.

This is supported by Swan and Hughes [1993], who see learning as being a social process needing sharing rather than the transmission of content. They see the use of class time almost exclusively for co-operative group work letting the students gather information outside of class.

Conclusion

The diversity of the student population can be an advantage rather than a disadvantage if a constructivist approach is followed provided that one can encourage all the students to participate. In student discussions, the students should all be able to have their say and express their understanding of the problem and solution. The students must be able to, not only defend their view, but also listen to other people's points of view and learn from them.

These days academic skills must be linked to skills like self-sufficiency, life-long learning, critical thinking, cooperation and teamwork so that students are able to deal with an environment where change is the only constant [Hamm & Adams, 1992].

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