An Educational Enquiry into the use of Concept Mapping and Multimedia to Enhance the Understanding of Mathematics

By

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ABSTRACT

This dissertation investigates the potential that concept mapping and the multimedia software Flash4.0 has for enhancing students' understanding of Mathematics. It focuses on developing the students problem-solving skills through use of concept mapping. The structuring of their solutions in a logical diagrammatic format through concept mapping will enable them to animate their Mathematical solutions through use of Flash4.0, thus creating a representation of their understanding of the Maths problem.

The participants in the study were a mixed gender class selected from Transition Year in the Irish second level education system. On the basis of the level that they took for their Junior Certificate Examination, Honours and Ordinary level groups were formed. Each group was ranked according to their Mathematical aptitude, identified from the results of Differential Aptitude Tests which measure: Numerical Ability, Abstract Reasoning, Mechanical Ability and Space Relations. They were then allocated into homogenous pairs, thus creating a collaborative learning environment.

An Action Research study was undertaken. Both groups took part in six sessions, presented over a three-week period, designed to develop, explore and examine the areas mentioned above, providing a more progressive methodology for the teaching of Mathematics. An evaluation of the study was formed based on the evidence gathered from: student journals, this practitioner's diary, video and audio tapes, questionnaires, learning styles tests, concept maps, and animations created in Flash4.0. Both groups were pre- and post-tested using a Mathematics question and those sections from the Differential Aptitude Tests that were mentioned above. The results showed that this methodology created an environment that enabled the students to develop positive attitudes towards Mathematics. Concept mapping and the use of multimedia motivated them to become active participants in their own learning process, increased their confidence in the problem-solving cycle, and facilitated the perception of Mathematics through their 'eyes'. The findings show that both the Honours and Ordinary level students improved in Abstract and Mechanical reasoning, and Space relations as a result of this enquiry. However the degree of improvement achieved by the Ordinary level students compared to the Honours students was significant. This methodology enhanced the student's enjoyment, understanding, and appreciation of Mathematics.

1 INTRODUCTION

This enquiry seeks to investigate the potential that concept mapping and multimedia may have on improving the problem solving skills of students, while enhancing their understanding of Mathematics. A group of students from Transition Year were chosen to participate in six sessions. The group consisted of students studying both Honours and Ordinary level Mathematics. The main objective of the enquiry was to provide an active and collaborative learning environment, in which students could elicit previous knowledge and develop or construct new knowledge through applying new technologies and skills, thus facilitating meaningful learning. In particular that the students develop an appreciation for Mathematics, thus enabling them to create Mathematics for themselves.

Prior to carrying out this enquiry I had identified two areas that were of interest and concern to me as a teacher: identifying an effective methodology for the teaching of Mathematics, and developing the use of Information and Communication Technology (ICT) within the Mathematics class.

This led me to carry out a pilot study in 2000, to explore the possibility of students developing multimedia authoring, Flash4.0 as an educational tool in teaching Mathematical concepts. The result of this study proved positive. Due to this positive response of the students as a result of using Flash4.0 to develop their understanding of different Mathematical concepts, I realised that further study in this area had exciting potential.

Role of The Teacher

As stated in the literature, since the Irish Mathematics curriculum review process was initiated in 1966, no reference was made to teaching methodologies. In March 2002 all schools were provided with a copy of the guidelines for the new revised syllabus for the revised Junior Certificate syllabus from the Department of Education and Science and the National Council for Curriculum and Assessment (2002). It focuses primarily on progressive methodologies that should be incorporated into a traditional Mathematics class. The guideline also outlined the qualities that an effective Mathematics teacher should display in their teaching. Previously this was the sole responsibility of the teacher. Teachers are encouraged to reflect on their practice, and on what made a lesson good or bad, or the difficulties that students' encountered during the lesson. Action research and peer observation are methods suggested in the guidelines. This method is adopted for the purposes of this enquiry and will be discussed below.

Schools IT 2000

The schools IT 2000 project has similarly placed increased emphasis on integrating IT into subject areas. The summary of the impact of "Schools IT 2000 project" (published, 2001) states that in post-primary schools competency in the use of ICT needed to be enhanced by additional training. Teachers who do not feel confident in the use of software and hardware will inhibit the success of ICT in the classroom. Traditional classroom management and teaching styles need to be re-considered if the lesson using IT is to be successful. The learning environment must become more student-centered and the teacher needs to be willing to relinquish some authority and become facilitator, guiding the learner through the learning process. The role that the teacher takes on is that of "Guide on the side" (MCKenzie, 1998).

Motivation for the study

The enquiry seeks to explore the possibility of integrating multimedia into the classroom, as an educational technology to aid the learning of Mathematics, addressing the Schools ICT 2000 initiative. To form a theoretical basis and context for this enquiry, research in the following areas has been examined and is outlined in this section:

- Junior Certificate Mathematics Syllabus,
- Multimedia as an aid to learning,
- Concept Mapping as a learning tool
- Problem-solving skills in Mathematics.

Junior Certificate Mathematics Syllabus

The following points have been the main focus of discussion during the course of the literature reviewed for the purpose of this enquiry. The main concern with regard to Mathematics curriculum is that emphasis needs to be placed on methodology if the learning objectives set down in the Guidelines for Teachers by the Department of Education and Science and the National Council for Curriculum and Assessment (2002) are to be realised where an increased depth of understanding, effective communication, and appreciation and enjoyment of Mathematics is experienced. Learning tools such as multimedia can be incorporated into the classroom, to actively engage pupils in the learning process, allow them to develop problem solving skills, by identifying connections and patterns in their work. Formative assessment should become more widespread, giving pupils the opportunity to take responsibility for their own learning process, thus increasing confidence and awareness for Mathematics.

Multimedia as an aid to learning

Research shows that use of multimedia allows the learner to have control over his/her learning by it been self-paced, and learners can become actively engaged in constructing knowledge. Learning is enhanced by use of visuals, sound, text and motion. These features offered by multimedia software have also shown to aid in recall. This author has found that making use of visual representations to teach Mathematics produces very positive results for the learner.

Concept Mapping as a learning tool

Pupils can organize and represent what they know through use of concept mapping. This method allows for teachers to assess any misconceptions that a pupil may have with regard to subject content, thus providing valuable information to both teacher and pupil where difficulties lie, enabling positive constructive action to be taken by both to facilitate further learning to occur. Another feature of concept mapping is that it promotes higher order thinking, which allows meaningful learning to occur, and is more effective when done in a collaborative environment. Research has also shown concept mapping to aid in the development of problem solving skills. Various evaluation and scoring schemes have been devised for assessing concept maps. However, it is important to state, that for the purposes of this study they will not be used, as the author's purpose of using concept mapping is to aid in problem solving and in the creation of a multimedia design.

Problem-solving skills in Mathematics

Problem solving skills can be improved, depending on the methodology used and the work environment provided. Pupils should be encouraged to become active problem solvers, understanding the "why" behind the various approaches taken to solve Mathematical problems. Research has shown that collaborative learning environments encourage pupils to develop problem-solving skills, as does use of learning tools such as computers.

The above findings gave rise to serious reflection and facilitated in the design and implementation of the study undertaken by the author. The following section will focus on the purpose of the enquiry and the research method used, that of Action Research.

2 ACTION RESEARCH

Action Research process was used in this enquiry. The purpose of this method of research is to enable practitioner to systematically reflect on practice, implementing informed action to bring about improvement in practice. This approach differs from other forms of research, where the practitioner or researcher is the observer of other practices. McNiff, Lomax and Whitehead (1996) use the following questions to distinguish between Action Research and other forms of research. Action Research is the only methodology, which can answer the question:

"How can I improve the process of education here?"

Meaningful research is enquiry conducted too make a contribution to the advancement of knowledge aimed at improving understanding or performance. Action Research is a specific formalized method of research whose main focus is to bring about such advancement in knowledge as is required to achieve an improvement in professional practice. The specific process of Action Research includes inquiry into the action or issue itself together with the methodology and personal values of the practitioner. In effect the aim of Action Research is to improve a situation through a careful evaluation of action leading to improvement. (McNiff, Lomax & Whitehead, 1996)

Key characteristics of Action Research is the tendency to be working intentionally towards the implementation of ideas that come from deeply held values that motivates one to intervene in particular situations e.g. we have something relevant to say that others in the public arena will find useful and that we have convincing evidence to support what we claim to know. Another benefit of Action Research is that it is possible to employ both qualitative research techniques and quantitative research techniques. Both techniques were used in this enquiry.

Implementation of the Enquiry

This chapter describes the procedures adopted in investigating the potential that an active learning methodology, utilising both a multimedia authoring tool and concept mapping, can have on enhancing a group of Transition year students understanding of Mathematics. The main focus for exploration will be that of Area and Volume.

The group for this enquiry comprised 10 girls and 10 boys from the Transition year. All the students had completed the Junior Certificate Examination. The enquiry was carried out over a three-week period (18.5hours). I introduced them to concept mapping to help them understand its benefits as a problem-solving and learning tool. I explained that concept mapping was used to help acquire, transform and construct knowledge (Huai-1997). I described the traditional steps undertaken when solving Mathematical problems according to Poly's problem solving phases (1954)

- Understand the problem
- Devise a plan
- Carry out your plan
- Look back

The students used concept mapping to solve a Maths problem chosen from a Junior Certificate Examination Paper. This will be discussed in more detail below. The students then learned Flash4.0 in pairs and began to animate their Mathematical solutions.

Use of the Differential Aptitude Tests (DATs)

The Differential Aptitude Test was produced in 1972 by the Psychological Corporation on Ireland and subsequently revised in 1975 for use in the Irish Educational System by the Educational Research Centre located at St. Paricks College in Dublin. Secondary schools use the DAT's tests to assess student aptitudes. For the purpose of this enquiry students Mathematical ability will be assessed by use of Numerical Ability, Mechanical Reasoning, Abstract Reasoning and Space Relations questions given in a standardised format, held in a controlled environment and supervised by a specially trained and certified Career Guidance Councilor.

Differential Aptitude Test Procedure

My approach was in accordance with best practice use of this test since a 5-month lapse was allowed between tests – the pre-test was carried out on 10th December 2001 and the post-test was carried out on 30^{th} April 2002. This time lapse was necessary to ensure that the results are valid.

Furthermore, strict procedures were followed for administering and scoring the DAT's test ensuring they were correct and valid. The Career Guidance Councilor administered the exam because she is the only member of the staff professionally qualified to do so. The tests were graded by The Educational Research Center. The time allocated for administering the exam was 2.5 hours plus an allowance for a short break between each of the four tests.

Students were organized into pairs based on the results of the Differentiated Aptitude Tests. The mean percentile rank for each student was calculated using the mean of the pre-test DATs. Both Honours and Ordinary level students were assigned to an Honours and Ordinary level group. The groups were then ranked in order of ability based on their average percentile rank achieved across four tests: Numerical Ability, Mechanical Reasoning, Abstract Reasoning and Space Relations. Both the Honours and Ordinary level groups were paired on the basis of equal aptitude, and assigned an identification letter for ease of reference.

Choice of Junior Certificate Mathematics Question

The students in the Transition year group that are involved in the enquiry have been taught Mathematics by a traditional methodology. The results that they obtained in the Junior Certificate Mathematics Examination reflect the standard and level of problem solving skills that they achieved through traditional methods of teaching. The results that they receive in the pre-test DATS reflect their aptitude in Mathematics having competed one formal cycle of the secondary level curriculum.

Their knowledge base in the comprehension of Mathematics for the senior cycle would not be adequately developed for use of questions from that cycle, therefore Junior Certificate papers were offered to all students so that they could select a suitable question for the entire group to use for the enquiry.

I concluded, from preparatory enquiries, that the results of improvements in learning due to my new methodology can be more clearly analysed if an official Junior

Certificate Examination paper is used rather than a pre-test and post-test designed by myself.

Teaching Methodology and Educational Values

My role as practitioner in implementing this methodology will be to reflect on my educational values that I as an educator have which has stemmed from my experience as a Mathematics teacher. Throughout this enquiry I will describe and explain how I will live these values in practice. I as practitioner believe that it is important to encourage students to become actively involved in the Maths class. I hope to establish this involvement through creating a student-centered learning environment, giving the students choices, encouraging them to design and create Maths as they perceive it, encourage communication and dialogue with their partner, give them an opportunity to present and explain their Mathematical creations. I wish to encourage exploratory learning based on Piagets theory that a “ child learns by exploring, manipulating and examining objects which leads to understanding and theories” (Bee, 1995).

This method places emphasis on incorporating ICT into the classroom. It is important to note that students have different learning styles and that the aim of this enquiry is to establish if my method will improve for a particular learning style that may not be achievable through a traditional methodology.

3 EVALUATION

The evaluation of an Action Research enquiry requires rigorous validation. The evaluation for this enquiry is based on both qualitative and quantitative data. Claims and results, which may arise as a result of this evaluation, must be thoroughly supported by evidence. Evidence gathered to support both qualitative and quantitative claims was provided by a number of the following methods: Student journal, Practitioner journal, Video & Audio tape recordings, Questionnaires, Pre- and Post Math questions, Pre- and Post DATs, Learning Styles Test, Animation designs.

Claims that are made throughout this evaluation will be based on judgments made about the standards of practice I chose to observe throughout this enquiry. It is through living my own educational values in my practice that I can validate claims to bring about improvement in the students learning. To facilitate this validation process, validation groups were formed to discuss the above. The first validation group involved critical friends and my supervisor. The second validation group had two meetings. The first was via on-line conferencing with Jack Whitehead a lecturer in Education at the University of Bath. The second of these validation meetings involved fellow M.Sc students and our supervisor.

The process of triangulation provides a means to afford rigour to claims made. This process is facilitated by the validation groups and the various data gathering techniques used throughout this enquiry.

The evaluation process will consider the impact of the above and to what extent I achieved the objectives of the study when examining the following: Evaluation of Concept Mapping, Evaluation of Multimedia, Analysis of Learning Styles, Analysis of Differential Aptitude Tests.

Evaluation of Concept Mapping

Concept mapping was used during the course of this enquiry to develop problem-solving skills and to facilitate the design of animation. Evaluation of the impact that concept mapping had on the students is assessed based on observations and data gathered from three pairs from the Honours level group and three pairs from the Ordinary level group who were selected from the group due to having different aptitudes in Maths.

I found that the concept mapping aided the students in solving the Mathematics problems, in helping them to establish the steps required to solve the problem and arrive at a solution. This was clear from the student’s journals, videotape and concept maps. The Ordinary level groups solutions through use of concept mapping were very clear, concise and logical. This level of clarity would be difficult to achieve in a traditional classroom. The Honours level group on examination of their concept maps showed that some of their work was correct but not very clear. The steps were not as structured and clear for a number of the students. Students learning together in pairs tended to produce similar maps. This may indicate that a collaborative environment through facilitating dialogue encouraged students to discuss their concept maps, thus enabling them to clarify the steps involved in solving the problem. Both groups had different opinions on the benefits of using concept mapping for Maths. These opinions were evident in the student's journals, the videotape, and from the information gathered from the questionnaire issued at the end of the enquiry.

The students also designed concept maps to establish the various stages of development that their animation would take as they created it using Flash4.0. Based on evidence from the student's journals, their concept maps and the video, it was clear that this method facilitated the transferring of their Mathematical solutions to animation representations. They required no assistance from me when designing their animation suggesting that concept mapping worked well as a tool for improving problem-solving and constructing a representation of the students understanding of the math problem. This method also encouraged exploratory learning to occur, increasing the students' confidence. They became the main decision makers and consulted me when problems arose that neither partners could solve. They were becoming responsible for their own learning process. The students saw that concept mapping had benefits and stated that it could be used in the following subjects: History, Geography, Science, Business studies, English [essay writing] and as a study aid.

Evaluation of Multimedia

Analysis of the impact of the use of Flash4.0 as a multimedia tool during the course of this enquiry is based on the observations and data gathered from the pairs selected from the Honours level group and the Ordinary level group. Both groups progressed through the eight lessons available with the software at a fairly moderate pace. I had anticipated that this would have taken longer based on the observations made during the course of the pilot study carried out in 2000, discussed earlier. Different students had technical difficulties with features of the software, which I clarified. They progressed to animating simple objects early on in the enquiry. It became evident that they were deriving great enjoyment from using the software when they successfully managed to create animations.

An observation made during the enquiry was that the Ordinary level groups confidence improved as they realised that this was a task that they could complete. The opinions and reactions of the other students was not an inhibiting factor in their progress, which can be evident in traditional Maths classes. Both groups listed the following mathematical topics that they would like to learn through animation: Area & Volume, Trigonometry, Theorems, Algebra, Sets, Speed & Distance.

Analysis of Learning Styles

A Learning Styles test was issued to the whole group [Honours & Ordinary level students] in order to identify the different ways in which the students may elicit and construct knowledge. Felder and Soloman, North Carolina State University designed the test. Felder & Solomon (2002) different learning styles are: Active and Reflective learners, Sensing and Intuitive learners, Visual and Verbal learners, Sequential and Global learners

The analysis of the student's tests showed that there is a moderate balance between Sequential and Global learners. This balance is more inclined towards Sequential for the Honours level students. This group follows logical linear steps when solving problems. If they concentrate on developing their global learning skills, it will enable them to gain a deeper understanding of topics. In comparison, the students studying Ordinary level Mathematics are more inclined towards Global learning. They require the overall picture before they can effectively solve a problem. They need to be able to establish connections between old information and new information, allowing them to apply new knowledge in novel ways. Concept maps can aid in establishing these connections.

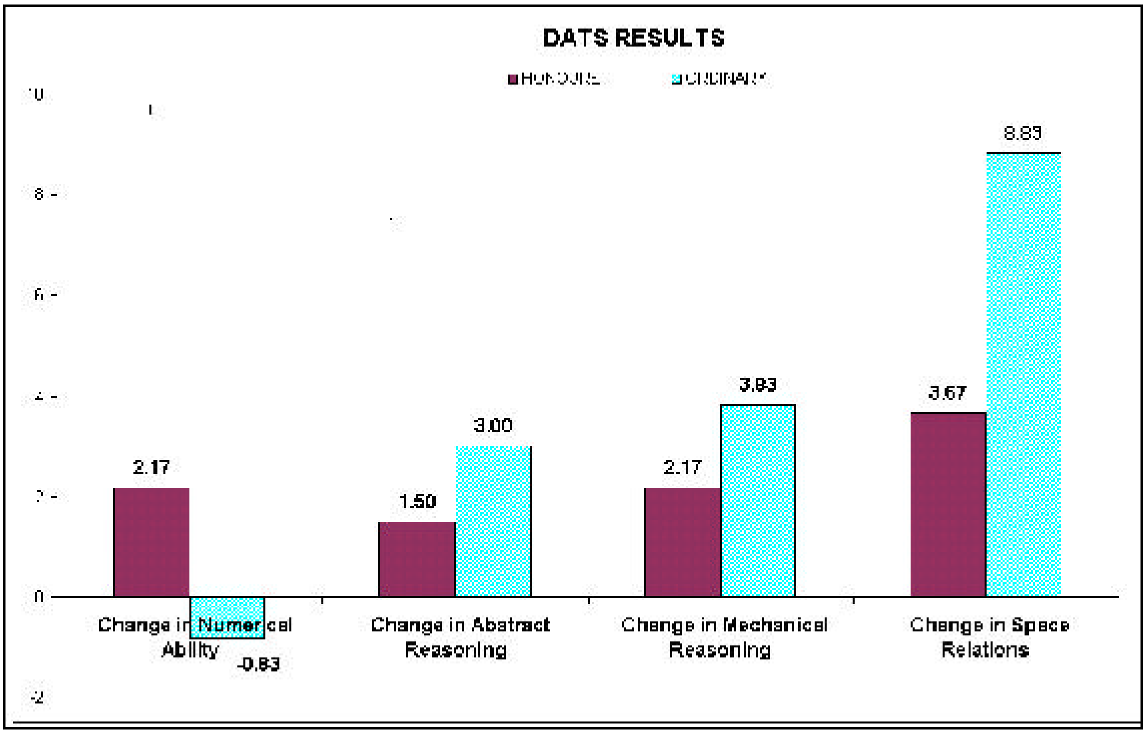
Analysis of Differential Aptitude Tests (DATs)

Quantitative methods were used to analyse the results of the Mathematical aptitude tests of the Differential Aptitude Tests. The statistical software package, Statistical Package for Social Sciences (S.P.S.S) was used to analyse the data. It is must be stated that for the purposes of this study that the data was gathered from only one group, which was divided into both Honours and Ordinary level groups. The analysis of the study is as follows: Descriptive statistics of the change in the raw scores for the Honours and Ordinary level groups, Hypothesis testing performed on students' percentile rank scores.

Descriptive Statistics

The descriptive statistics display measures of central tendency and dispersion of changes in raw scores. The following table, recorded after the post-testing, displays the change in scores for the Honours and Ordinary level groups. Both groups consisted of three homogenous pairs, which were selected from the groups at an earlier phase in the enquiry.

Group		N	Min.	Max.	Mean	Std.Deviation
Ordinary Level	Change in Numerical Ability	6	-9	7	-0.83	5.672
	Change in Abstract Reasoning	6	0	8	3	3.098
	Change in Mechanical Reasoning	6	-2	9	3.83	3.869
	Change in Space Relations	6	2	19	8.83	7.223
Honours Level	Change in Numerical Ability	6	-1	7	2.17	2.714
	Change in Abstract Reasoning	6	-2	5	1.5	2.881
	Change in Mechanical Reasoning	6	-5	14	2.17	6.494
	Change in Space Relations	6	-11	12	3.67	7.815



The scores for both groups improved during the period of this enquiry. It is clear from the table that less improvement occurred in the Honours level group when compared with the Ordinary level group. The Ordinary level group showed significant improvement for three of the DATs' compared to that of the Honours Level group. However the Ordinary level group shows no improvement for Numerical Ability compared to the Honours level Group.

Hypothesis Testing of DATs' Scores

As the group [Honours and Ordinary level] was statistically small in number, a one tailed student t-test for independent samples was determined to be a suitable test for homogeneity of the whole group [Honours and Ordinary level], based on Mathematical ability. The percentile rank scores from the pre- and post-tests were used as the test data.

Hypothesis 1

The descriptive statistics discussed earlier showed that the scores of both the Honours and Ordinary level groups improved as a result of this enquiry. Therefore no test was carried out on the pre- and post-test scores. A one-tailed, two sample t-test was used to test if there was any significant difference in improvement in scores between the Honours and Ordinary level groups, as a result of the treatment. This was also used because the sample was normally distributed and homogenous based on Mathematical ability. The null hypothesis stated that there was no mean difference in improvement between the Honours level and Ordinary level groups on completion of this enquiry. The alternative hypothesis stated that there was a greater improvement in the mean scores of the Ordinary level group when compared to the mean scores of the Honours level group. Levene's test for equality of variances proved that there was no significant difference therefore equal variances could be assumed for all four DATs in both groups.

Levene's Test	Change in Numerical Ability	Change in Abstract Reasoning	Change in Mechanical Reasoning	Change in Space Relations
p-value	0.127	0.754	0.339	0.786

For each test, the p-value was greater than 0.05 so the null hypothesis, that there was no difference in variances, was not rejected.

T-TEST for Equality of Means of Two Independent Samples					
	t-value	df	Sig	Mean Difference	Std. Error Difference
Change in Numerical Ability	-0.97	10	0.356	-8.67	8.949
Change in Abstract Reasoning	0.464	10	0.652	2.83	6.101
Change in Mechanical Reasoning	0.417	10	0.685	3.83	9.185
Change in Space Relations	1.381	10	0.197	15.67	11.341

The calculated t-value for the Numerical Ability was -0.97. The critical value for 10 degrees of freedom, at a 5% significance level, was 1.81. Since the calculated t-value was less than the positive critical (tabulated) t-value, the null hypothesis was not rejected for Change in Numerical Ability. It was therefore accepted that no significant improvement in Numerical Ability on the Ordinary level group when compared with the Honours level group as a result of the treatment.

The calculated t-value for the Abstract Reasoning was 0.464. The critical value for 10 degrees of freedom, at a 5% significance level, was 1.81. Since the calculated t-value was less than the positive critical (tabulated) t-value, the null hypothesis was not rejected for Change in Abstract Reasoning. It was therefore accepted that no significant improvement in Abstract Reasoning occurred in the Ordinary level group when compared with the Honours level group as a result of the treatment.

The calculated t-value for the Mechanical Reasoning was 0.417. The critical value for 10 degrees of freedom, at a 5% significance level, was 1.81. Since the calculated t-value was less than the positive critical (tabulated) t-value, the null hypothesis was not rejected for Change in Mechanical Reasoning. It was therefore accepted that no significant improvement in Mechanical Reasoning occurred in the Ordinary level group when compared with the Honours level group as a result of the treatment.

The calculated t-value for the Space Relations was 1.381. The critical value for 10 degrees of freedom, at a 5% significant level, was 1.81. Since the calculated t-value was less than the positive critical (tabulated) t-value, the null hypothesis was not rejected for Change in Space Relations. It was therefore accepted that no significant improvement in Space Relations occurred in the Ordinary level group when compared with the Honours level group as a result of the treatment.

There was no significant difference as the sample was too small. Due to there being no significant difference between both the Honours and Ordinary level groups it was acceptable to pool both groups. The results of this test are outlined in Hypothesis 2.

Hypothesis 2

The descriptive statistics discussed earlier outlined that the scores of all the students improved as a result of this enquiry. Therefore a test was not performed on the pre- and post-test scores. A one-tailed, one-sample independent t-test was used to test if there was any significant difference in the improvement in scores of all the students, as a result of the treatment. The sample was normally distributed and homogenous based on Mathematical ability. The null hypothesis stated that there was no mean difference in improvement of all student scores on completion of this enquiry. The alternative hypothesis stated that there was an improvement.

T-Test for Equality of Means of One Independent Sample				
	t-value	df	Sig	Mean Difference
Change in Numerical Ability	0.954	15	0.355	3.31
Change in Abstract Reasoning	3.292	15	0.005	8.5
Change in Mechanical Reasoning	3.692	15	0.002	12.38
Change in Space Relations	2.335	15	0.034	10.88

The calculated t-value for the Numerical Ability was 0.954. The critical value for 15 degrees of freedom, at a 5% significance level, was 1.75. Since the calculated t-value was less than the positive critical (tabulated) t-value, the null hypothesis was not rejected for Change in Numerical Ability. It was therefore accepted that no significant improvement in Numerical Ability occurred in all the students' scores as a result of the treatment.

The calculated t-value for the Abstract Reasoning was 3.292. The critical value for 15 degrees of freedom, at a 5% significance level, was 1.75. Since the calculated t-value was more than the positive critical (tabulated) t-value, the null hypothesis was rejected for Change in Abstract Reasoning. It was therefore accepted that a significant improvement in Abstract Reasoning occurred in all the students' scores as a result of the treatment.

The calculated t-value for the Mechanical Reasoning was 3.692. The critical value for 15 degrees of freedom, at a 5% significance level, was 1.75. Since the calculated t-value was more than the positive critical (tabulated) t-value, the null hypothesis was rejected for Change in Mechanical Reasoning. It was therefore accepted that a significant improvement in Mechanical Reasoning occurred in all the students' scores as a result of the treatment.

The calculated t-value for the Space Relations was 2.335. The critical value for 15 degrees of freedom, at a 5% significant level, was 1.75. Since the calculated t-value was more than the positive critical (tabulated) t-value, the null hypothesis was rejected for Change in Space Relations. It was therefore accepted that a significant improvement in Space Relations occurred in all the students' scores as a result of the treatment.

4 CONCLUSION

The purpose of my enquiry was to establish if the use of concept mapping and multimedia Flash4.0 could enhance the students understanding of Mathematics. In my experience students tend to have difficulty in structuring their solutions in a traditional Maths class. Concept mapping acted as a visual tool and guide for logically structuring their steps in a clear concise path. It allowed the students to identify the next step that should be taken to arrive at the solution and provide visual confidence-enhancing affirmation. They had to actively construct the solution, which facilitated meaningful learning to take place.

Compared to a more traditional Mathematics class, students accepted more responsibility as they managed to work through the question, with their partner. Through this enquiry the students problem-solving techniques were enhanced through use of concept mapping. Both groups appreciated the benefits from using such a method. However the Ordinary level students derived greater benefit from using concept mapping, which was evident when they all solved the post-Maths question using concept mapping. Of the three pairs that I chose to observe from the Honours level group, they all reverted back to traditional methods for solving the post-test question. This small sample commented that they did so because they found the traditional method more comfortable.

Concept mapping facilitated the transfer of the solution into animation format The students were able to establish the individual steps that they needed to implement in Flash4.0 by designing another concept map structured on their initial map, which outlined the solution for the Maths question. It is important to note that the students took responsibility and required no help from the teacher with this stage in the design process.

The use of multimedia as an educational tool gave the students the facility to create their personalized Mathematical perception, to create a representation of their understanding of the Maths solution and apply it through animating it in Flash4.0. In a traditional Maths class the diagrams that the teacher may introduce are a reflection of that teacher's understanding. Therefore this does not always help the students in understanding the Mathematics themselves. Multiple data gathered over the course if the study shows that the software allowed the students to explore their understanding, a process that they enjoyed. A product of this process was that the majority of the students in this study developed a more positive attitude towards Mathematics through taking ownership of their work, leading to them becoming more responsible for their own learning. It was also evident that these students became active decisions makers in relation to their Maths work, which became the intrinsic motivating factor for them to work productively throughout the enquiry. It is clear from the animations that they designed that they had gained a better understanding of the Maths question. They had come to understand "what" they were doing and "why" they were doing it, and "how" to do it. Within the content of this study it is clear that both their instrumental and relational understanding had improved as a result of this enquiry.

A collaborative environment enabled dialogue and communication to take place in the classroom. The students gained support and confidence from working through various stages with their partner. They were able to discuss the differences and similarities in their approach to solving the Maths question and in designing their animations by comparing their individual concept maps. It was evident that they were more willing to listen to each other's points of view as the enquiry proceeded. I was able to facilitate this process by offering support and guidance.

Within the traditional Mathematics classroom the students have a variety of different learning styles. Therefore it is necessary to ensure that the methodology that we choose to use caters for different learning styles. This approach will help to ensure that individual students achieve their full potential as they progress through the educational system.

From my experience as a Mathematics teacher I always thought that traditional Mathematics classes do not adequately facilitate active, global and visual learners. My intention of the enquiry was to cater for all learning styles and I consider that this methodology caters for all learning styles. Concept mapping and the use of multimedia through group work created an environment that facilitated more discussion and facilitated the active learner. It is evident that concept mapping helped global learners to get the "big picture" with regard to the Mathematic problems by helping them to establish connections in the steps taken to solve the problem. Both groups were very strong visual learners, therefore concept mapping allowed the students to represent their Mathematics in diagrammatic format, and multimedia in a 3-dimensional format. An important observation arising from this enquiry is that the Ordinary level group were more inclined towards being active and global learners when compared to the Honours level group.

The methodology used in this enquiry shows some improvement has taken place in the groups [Honours & Ordinary level students] understanding of Mathematics. The statistical analysis of the pre- and post Differential Aptitude Tests showed that an improvement occurred in: Abstract reasoning, Mechanical reasoning, and Space relations for all students who participated in the enquiry. The pairs selected from the Ordinary level group showed significant improvements in: Abstract reasoning, Mechanical reasoning, and Space relations when compared to those selected from the Honours level group. However, the Ordinary level group showed little or no change in Numerical Ability when compared to the Honours level group, who did improve.

It is clear from the above that both the Mathematical skills and Mathematical ability of both groups improved as a result of the methodology used during the course of this enquiry. However the Ordinary level students showed greater improvement.

Winter (1989) outlines six main principles for conduct of Action Research: 'reflexivity', 'dialectics', collaborative resource', 'risk' and 'theory practice and transformation'. Reflexivity insists upon modest claims and questioning these claims. During the course of this enquiry based on observations made, I as practitioner was able to examine and reflect upon my practice and the impact that it was having on the students learning. The claims made as a result of this modest enquiry are based on judgments that were derived from the context of this single subject study. These claims may be transferable to other subjects (e.g History, Technical Drawing, Science, Geography – were listed by the students themselves).

Dialectics starts with a notion of contradiction. The contradiction existed between the educational values that I held and those that I practiced in my teaching. This enquiry allowed me to implement a methodology for Mathematics, which reflected and permitted me to "live" my values in my practice. Throughout this enquiry I have put into practice my educational values, these values I can now use as standards of judgment to make claims about knowledge of my own practice.

Action Research involves working collaboratively, taking other peoples viewpoints into consideration. Through establishing a validation group and identifying critical friends, an environment was created in which other people could question my statements and actions, enabling me to become more aware and focused, gaining insight into my practice and the reasoning behind my research, providing evidence of my claims.

With Action Research you put yourself at risk through the process of investigation. By admitting that your practice is capable of improvement, and engaging in a process that will allow you to change and improve on that practice, hoping that you can contribute to a living educational theory, you take a personal risk.

Winter (1989) states " theory and practice are not two distinct entities but two different and yet interdependent and complementary phases of the change process". In Action Research the theory being based in practice is itself transformed by the transformation of practice. The research is brought about by a change in practice, which informs the theory. Consequently theory and practice need each other. By a process of reflecting and improving my practice I realised that I was not living out my educational values. Through the process of this enquiry I was able to more successfully live these values and improve student learning as is evident from the study. The learning environment became active and student-centred as opposed to passive and teacher-centred. Through my practice I was able to create my own 'living theory'. According to McNiff, Lomax and Whitehead (1996)

> *"If you can provide a validated account of how you have improved education through your Action Research, you have contributed to the creation of 'living theory."*

My theory is that to improve the educational system we must look beyond classroom constraints to address cognitive and psychological issues that cause "good" students to perform poorly and that rewards some students but leaves others behind. By using concept mapping and multimedia in a collaborative learning environment, hidden strengths are discovered, synergistic communication can flourish, student learning skills are improved and learning performance is enhanced – the teacher becomes catalyst and the student is empowered.

During the course of this enquiry the students through making decisions, became responsible for their own learning, providing me with the opportunity to relinquish an authoritarian role, creating a learning environment that was positive, productive and interactive, where I facilitated their learning. We learned together and were more willing to admit that we didn't have all the answers. This honesty fostered a more trusting environment, a feature that is difficult to establish with Transition year students. The dialogue that occurred between the students and I was very dynamic and interesting. In a traditional classroom teacher-instruction is generally followed by questions from the students, and then the teachers response. However during the enquiry the students explored their understanding of the Maths problem through discussions with me, centred on their concept maps and animations. They were thinking for themselves and they realised that their opinions were important. Their creative intelligence flourished in a subject that for most of them and society can become an inhibiting factor in their development and self esteem.

Recommendations

- This active methodology, which demonstrated the impact that concept mapping and the use of multimedia can have on the learning of Mathematics, should not be used in isolation. It should be implemented as a progressive methodology in conjunction with the existing traditional methodologies, to cater for all learning styles, creating a very dynamic learning environment.
- The role of the teacher is very important ensuring that concept mapping and multimedia are used successfully in the classroom. Teacher intervention is

necessary in order to support and guide the learning process, encouraging the students to examine their existing knowledge on the topic and explore new possibilities and solutions.

- Concept mapping and the use of multimedia is best facilitated in a collaborative learning environment, enabling students to communicate the differences and similarities in their understanding of Mathematics, facilitating further exploration and meaningful learning. It flourishes in the very collaborative environment it fosters.
- This methodology requires a structured and task-oriented environment. The teacher needs to scaffold the learning process, actively engaging the students in the session in order to build confidence.

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