TEACHING STUDENTS TO PROVE BY USING ONLINE HOMEWORK
Buma Abramovitz¹, Miryam Berezina¹, Abraham Berman²,¹Department of Mathematics, ORT Braude College, Karmiel, Israel ²Department of Mathematics, Technion – IIT, Haifa, Israel

Abstract
We give two examples of using homework online assignments to direct students to prove, on their own, theorems in calculus. One example is Green's theorem in a rectangle. The second is the basic theorem of calculus.

Mathematics, the first step in the evolution of understanding Physics: A preliminary investigation.
Mrs Nadine Adams, Learning and Teaching Services, Central Queensland University, Mackay, Australia
Mr Clinton Hayes, Academic Learning Services Unit, Central Queensland University, Rockhampton, Australia

Abstract
Arnold Sommerfeld, a German theoretical physicist, stated ‘If you want to be a physicist, you must do three things—first, study mathematics, second, study more mathematics, and third, do the same’ (as cited in Kevles, 1995, p. 200). The importance of mathematics appears to be lost in a modern world of open universities with an emphasis on social inclusion. As governments encourage universities to increase their enrolments and admit greater numbers of non-traditional students, enabling (bridging) programmes are assisting students to gain the prerequisite knowledge required for successful undergraduate studies. This paper will present the preliminary results of a study examining students enrolled in an introductory physics course as part of an enabling programme in regional Australia. In particular the focus of the study is to determine the effect prior mathematics courses have on learning outcomes for these students. Students enrolled in the Introductory Physics course are required to have a very basic level of mathematics but mathematics and physics staff believe the level should be higher. Unfortunately, decisions are made at a higher level; as with many policy decisions made, they are made without discipline knowledge or input.

Evolving formative assessment for and with ubiquitous technologies.
Nadine Adams & Anne Porter, School of Mathematics and Applied Statistics, Faculty of Engineering and Information Sciences, University of Wollongong, Australia

Abstract
Formative assessment is a vital part of the learning process. It guides student learning and prepares them for summative assessment. The feedback that accompanies formative assessment is valuable for students’ learning. The combination of formative assessment and feedback facilitate the development of self-efficacy. Technology is not only changing the way students study and learn but also how assessment is conducted and managed. Globalisation and corporatisation of universities has changed the way academics work and has had an effect on teaching, assessment and feedback. This paper looks at how formative assessment in an enabling mathematics course has been developed to take advantage of changing technologies in a changing academic world.
EARLY CHILD NUMERACY (ECN)

ADENEGAN, K. E., AKINREMI, O. V., and AKINROTIMI, A. A.

Department of Mathematics & Department of Early Childhood Care & Education, Adeyemi College of Education, Ondo, Ondo State, Nigeria.

Abstract

Early child numeracy (ECN) is a competence built in the young child at an early childhood stage in the mathematical skills needed to cope with everyday life and an understanding of information presented mathematically, e.g. in graphs, charts, tables, figures, objects, numbers, etc. Hence, this paper gives a descriptive and practically demonstrative outlook of the methodological aspect of early child numeracy (ECN). Pictorial representations were made with relevant points pivotal to facilitate the teaching-learning process for the young child. Recommendations were made to enhance effective early child numeracy (ECN).

Keywords: Early Child Numeracy (ECN), Mathematics, Education.

From notable occurrences to situated abstractions: a window for analysing learners’ thinking-in-change in a microworld

Anna Baccaglini-Frank*, Celia Hoyles**, & Richard Noss**

*Department of Education and Human Sciences, University of Modena and Reggio Emilia, Italy **London Knowledge Lab, Institute of Education, University of London

Abstract

This paper introduces an analytic framework developed to shed light on how activity in a computer-based microworld can foster the development of instrumented action schemes that support the construction of mathematical meanings. The framework is derived from the ideas of “scenario in use” and trajectories of evolving meaning, (Trouche, 2003; Hoyles et al., 2004), and is used to track key points where the design of a microworld can be shown to shape students’ interactions and their development of situated meanings. To exemplify the proposed framework, we report its application to students’ activity in eXpresser, a microworld designed to support the development of the notion of variable through activities that involve building and colouring figural patterns. We note how the use of the framework helped to highlight aspects of students’ thinking-in-change while interacting with eXpresser, thus making the trajectories more visible and thus more easily compared to one another and to ‘intended schemes’.

Sex, Religion and Statistics

Mike Bedwell, Ukrainian Education Center, Kyiv

Abstract.

In the UK and many other western countries, secondary schools are required, even legally obliged, to teach two personally sensitive and controversial subjects, sex and (comparative) religion. Most mathematicians may be glad that they are rarely called on to take these classes, yet they are routinely expected to teach statistics, a subject less sensitive but no less controversial. This paper proffers advice to teachers who may come to statistics in innocent ignorance of these controversies.
Paradox in the Teaching of Mathematics
Larry G. Blaine
Plymouth State University, Plymouth, New Hampshire, USA

Abstract
This paper presents an argument for the use of paradoxes in the teaching of mathematics, as a means of raising interest and sharpening reasoning skills. Based on the author’s experience in and out of the classroom, four representative examples of contrasting types have been selected and analyzed. A distinction is made between problems whose solutions violate intuition but are not otherwise questionable (not true paradoxes, in the logical sense) and those that are deeply enigmatic.

Developing algebraic thinking: providing new tools to understand mathematical relationships (Workshop)
George Booker

Abstract
This workshop will address problem solving as a basis for developing algebraic thinking with problem tasks and representations through the use of materials that allow insight into the underlying algebraic ideas and thus provide a bridge to the more formal algebra that will be developed later. An approach via problem solving, reflects both recent research (Lins, 1992; Radford & Puig, 2007; Windsor, 2010) and the way in which algebra developed historically (Katz, 2007). As solutions are obtained and described, generalisations can be formed among related problems, and ways of thinking developed that focus on the relationships within problems, building on a search for patterns among the representations chosen for the problems and their solutions.

Gatekeeping in Mathematics (Workshop)
Marcia M. Burrell, Ph.D., SUNY Oswego, Curriculum and Instruction Department

Abstract
How does one ensure the rigorous nature of mathematics for all, while properly preparing a diverse population for success in mathematics and in the STEM fields? Good research exists that tells us about what success in mathematics requires, but our consistent gatekeeper behaviors can be modified to create a space for more students to be challenged to do rigorous mathematics. This presentation will provide concrete recommendations about how to ensure the teaching of rigorous mathematics for all students, while maintaining and acknowledging the differences in experiences that students bring to the classroom.

Fractions, Ratios and Interactive Dynamic Technology
Gail Burrill, Michigan State University

Abstract
Researchers have investigated teaching and learning fractions, ratios and proportions for years. The Rational Number Project has been studying how children come to understand these concepts since 1979. Despite this wide spread and long standing work, the international average percent correct responses on PISA and TIMSS items related to fractions and ratios is typically from 30% to 50%, signaling that across the world, students in many countries struggle with those concepts, although some countries do extremely well. Scores in the United States are usually below the national averages. This paper looks at a shift in perspective in how fractions and ratios are treated in the U.S. Common Core State Standards for Mathematics.
(CCSSM, 2010), how this connects to the approaches used by some other countries, and how interactive technology can support this shift in perspective.

**Interactive Dynamic Technology: Teaching and Learning Statistics**
Gail Burrill, Michigan State University

**Abstract**
Technology is integral to teaching and learning statistics, both to “do” statistics and to learn statistics. Principles advocated by Dick (2008) can be used in selecting technology platforms for the second purpose, developing understanding of core statistical concepts. These principles are described in the paper and applied to a sample of technology options. Finally, a series of applet-like dynamically linked documents designed according to the principles are described as a potentially new way to support student learning of important statistical concepts, in particular, those outlined in the U.S. Common Core State Standards for Statistics.

Douglas Butler, iCT Training Centre, Oundle, UK

**Keynote + 2 Autograph workshops.**

**KEYNOTE:**
Technology must be transparent and not get in the way of teaching and learning
Software and hardware solutions for mathematics teaching are evolving all the time, leaving many teachers bewildered by the ever increasing kaleidoscope of possibilities. Douglas will attempt to bring this audience up to date with some exciting lesson plans drawing on a new generation of hardware independent resources, the emphasis always being to let the mathematics shine through.

**WORKSHOPS**

**TSM Resources**
Bring your own device and explore the myriad of web-based resources linked from Douglas' Technology for Secondary Mathematics website:

[www.tsm-resources.com](http://www.tsm-resources.com)

**Autograph for ages 11-16**
Although Autograph sits most comfortably on a Windows or Mac laptop or desktop, a version for tablets (IOS and Android) is evolving. This session will explore some well tried lesson plans for visualising basic concepts for the younger age group: transformations, exploring images, trig, 3D Pythagoras and data handling

[www.autograph-maths.com](http://www.autograph-maths.com)

**Autograph for ages 16-19**
Although Autograph sits most comfortably on a Windows or Mac laptop or desktop, a version for tablets (IOS and Android) is evolving. As the material gets more challenging, there are more profound opportunities for enhancing understanding through visualisation. This session will cover probability and statistics, and calculus and vector topics in 2D and 3D.

**An Intervention Strategy to Promote Intrinsic Motivation in Students Studying Mathematics for Diplomas in Engineering and Analytical Chemistry**
J. Coetzee, E. Oberholster & M. Mbebe, South Africa

**Abstract**
Conflicting claims have been made in literature regarding motivation and the value of rewards systems in education. Some theories and perspectives emphasise the harmful effects of rewards, while others regard these as a necessary part of learning and teaching. The objective of this study was to promote intrinsic motivation in students
of a mathematics course for non-mathematics majors. A quasi-experimental design was followed using pre-post testing. Approximately 300 students from a comprehensive university were involved in the study. The measuring instrument used was the Attitudes Towards Mathematics Inventory (ATMI). ANOVA did not demonstrate any significant differences in the experimental groups. Small differences were however detected in the control groups between pre-testing and post-testing. Key words: Motivation; rewards; attitudes; mathematics; self-confidence; value; enjoyment

SYMMETRY FESTIVALS IN THE CLASSROOM! THE HUNGARIAN EXPERIENCE WORKSHOP MOVEMENT IN THE EDUCATION OF MATHEMATICS AND SYMMETRY STUDIES THROUGH ARTS

György Darvas, Symmetrion, Budapest, Hungary & Kristóf Fenyvesi, University of Jyväskylä, Finland

Abstract

The Experience Workshop – Movement for the Experience Centered Education of Mathematics started in 2008 as a collaborative effort of scientists, artists and educators of the Ars Geometrica Conferences. We organize math-art festivals, workshops, exhibitions, trainings and conferences. In our workshops the implemented activities provide the students with unexploited experiences, never met at their school. Symmetry principles are used as a common guide to all these activities. They are, partly, a tool to repetition, to algorithms, to isotropy and isometry, to similitude, and so on, partly, to bridge a link between scientific truth and artistic beauty, between regularity and harmony. Talented students demand such new kind of information that cannot be included in the standard teaching programs. These workshops develop the creative thinking of the students by burdening their left and right cerebral hemispheres more-or less equally balanced.

Keywords: symmetry, experience, mathematics, art, education

Modelling with Algebra Tiles and Areas in Completing the Square of a Quadratic

Ysbrand de Bruyn and Gila Hanna

Abstract

Modelling algebraic problems with algebra tiles facilitates understanding of algebraic concepts and methods. In this paper we give examples of the use of algebra tiles in the context of changing the equation of a parabola from its standard form to its vertex form.

A PEDAGOGY OF “TEACHING THE TEST”

Du Toit Erna, Department of Education, Sol Plaatje University, Kimberley & Du Toit Jacqueline, Student support Services, Wellness Centre, Central University of Technology, Welkom, South Africa

Abstract

Mathematics is undoubtedly an essential subject needed to equip learners in mastering many other subjects. The inability to comprehend mathematics has become a major issue relating to the decline in learners’ mathematical performance. The objective of good mathematics teaching should not be to “cover the curriculum” or as in the context of this research “teach learners the test” but to show learners how to explore mathematics. In focusing on a pedagogy that merely addresses the need to pass or obtain good marks the focus is largely on irrelevant and uninteresting set of learning
objectives and not engaging for learners. In the context of this study evidence was gathered that mathematics in most cases were taught as a series of computations rather than a tool for solving open-ended and interesting problems. Moreover most learners were identified with a preference to the auditory learning style which implicated that learners are not actively constructing knowledge. The importance of relevance in teaching mathematics cannot be over-stated. Furthermore many learners disengage from learning mathematics because of an unsatisfactory pedagogy of coercion to force them into learning an unsatisfying curriculum such as only to improve the annual national assessment (ANA) mark. Therefor this study suggests a pedagogy that is more diversified to address a wider variety of learning styles and thus to improve the students' academic achievements in mathematics and enhance learning.

Reliability versus Reality
Du Toit Gawie, Department of Education, Sol Plaatje University, Kimberley, South Africa & Du Toit Jacqueline, Student support Services, Wellness Centre, Central University of Technology, Welkom, South Africa

Abstract
The performance of South African Mathematics and Science learners is of the worst as seen in the results of international tests such as TIMMS. While TIMMS gives insight into the international performance of our learners, is it equally insightful to take a look at South Africa’s unique situation on local and national level. In 2011 the Annual National Assessment (ANA) tests were nationally introduced into certain grades in an effort to support and improve the learning of Mathematics. This research investigated the poor performance of Grade 6 learners in ANA (Mathematics) in one of the education districts in the Free State province in South Africa. An explanatory mixed methods approach was employed to determine the teacher proficiency and the learner performance in Mathematic. The non-verbal reasoning ability of the learners was also determined to reveal the learners basic competence to analyze and solve complex problems.

The idea of using analogies
Wolfram Eid, Otto-von-Guericke-university Magdeburg eid@ovgu.de

Abstract
A typical form of thinking to approach problem solutions humanly is thinking in analogous structures. Therefore school, espacially mathematical lesson should help to form and to develop cor-responding heuristic abilities of the pupils.
In the contribution a summary of possibilities of the mathematics lesson regarding this shall par-ticularly be conveyed from the view of the geometry lesson in different age-groups. Being sup-posed to exemplarily be illustrated introducing character and object of making analogies at an example. Different kinds of analogous conclusions are described exemplarily at most with some examples for different geometrical contents and didactic situations.

Interdisciplinary Courses: a Personal Experience, Math, Art, Architecture
Michele Emmer, Dipartimento di Matematica, Università di Roma “La Sapienza”

Abstract
The paper elaborates on my experience with interdisciplinary courses between mathematics and a number of subjects (including art, architecture,...) over a number of years. These academic activities started as a personal experience more than 30 years
ago. For many years I was (and I still am) officially a full professor in Math and non-officially I worked on the relationships between mathematics, art, architecture, biology, physics, literature, cinema. At a certain point of my activity my work on art and math was recognized as official work in mathematics.

**From 2d to 3d geometry: discovering, conjecturing, proving**
Daniela Ferrarello – Maria Flavia Mammana – Mario Pennisi
Dipartimento di Matematica e Informatica
Università di Catania, Italy
ferrarello@dmi.unict.it - fmammana@dmi.unict.it - pennisi@dmi.unict.it

**Abstract**
Geometry is offered a small time in high school teaching, and, always more often, 3d geometry is even not done at all. This is due to several factors, from drawing difficulties and visual difficulties to lack of time.
Here we present a classroom activity that moving from 2d geometry brings students into 3d geometry in a “natural way”. Students face with some surprising analogies between figures of the plane and figures of the space. And even more surprisingly, the analogy still holds in proving those properties. We will also present the results of the activity that has been experimented in different classes of some high schools in Sicily.

**Investigating the Learning of Spatial Visualization with Physical and Virtual Manipulatives**
Beverly J. Ferrucci, Keene State College, Keene, NH USA

**Abstract**
Many tertiary institutions often institute programs that allow students to incorporate both their technological and pedagogical knowledge within a teaching research project. This paper reports on a research project conducted by a group of student researchers in which they analyzed preservice primary teachers’ use of digital, virtual manipulatives in comparison to their use of traditional, concrete manipulatives for a unit on spatial visualization. The project highlighted the two different pedagogical approaches and described the learning and teaching implications of such a project, as well as problems and potentialities related to the physical materials and the virtual technology.

**Using Partnership to Grow Elementary Teachers’ Content Knowledge Through Inquiry-Based, Collaborative, Mathematical Reasoning Workshops**
Dr. Doug Franks and Dr. Timothy Sibbald, Schulich School of Education, Nipissing University (Canada)

**Abstract**
This paper describes a partnership that builds mathematical reasoning and pedagogical capacity among elementary teachers using inquiry-based in-service workshops. This approach allows modeling of the instructional strategy and deepening of mathematical understanding. Partnerships among teacher leaders, mathematics educators, and mathematicians, function on the basis of shared goals, common understandings, and mutual respect. These are factors crucial to the success of the professional learning workshops

The influence of using concrete models on solving combinatorial problems of 5th grade students.
Avikam Gazit and Nitza Chay, The Kibbutzim College of Education, Israel

**Abstract**

Combinatorial analysis is one element of the branch of combinatorics and deals with combinations, permutations, non repetitive arrangements and repetitive arrangements. It can be defined as a principle of calculation involving selection and arrangement of items in the final group, according to defined conditions. In Piaget’s developmental theory, combinatorial analysis represents a basic component of formal reasoning ability. If a student does not master combinatorics, he will not be able to use the idea of probability, except for very elementary random situations (Piaget & Inhelder, 1975). Piaget & Inhelder conducted their research by using different concrete models, such as cards, discs, or dolls. The purpose of this research is to examine the influence of teaching process, using visual-concrete models, on the ability to deal with the different combinatorial tasks on 5th grade students. In both groups, the experimental and control, there was improvement in solving combinatorial problems, but the most significant finding was that in the control class, where the students learnt without visual concrete aids, there was greater improvement, as compared to the class using visual concrete aids. This result confirms the reservation of a number of researchers regarding the benefit attributed to visual aids.

**Incorporating research projects in the initial training programmes of Mathematic teachers: A South African case study**

Johanna L Geldenhuys

Nelson Mandela Metropolitan University, Port Elizabeth, South Africa

**Abstract**

Regardless of the post-1994 South African government’s hard work to put the necessary legislation in place and to transform the education system, many inequalities still exist. Yet, it is in these schools that many student teachers must do their teaching practice. Simultaneously these students were introduced to a Research Project module in their curriculum which required them to identify, design and execute a research project within their learning area, in this case Mathematics. This presentation reports on the experiences of two students’ involvement in their research project, which at the same time was an outreach program between a private school in Port Elizabeth and a disadvantaged school in Zwide Township. The aim of the project was to explore the possible advantages of cross-cultural peer teaching of some sections of the new Mathematics curriculum for the learners. Data were collected by both quantitative and qualitative methods. The results showed that the township learners’ mathematical understanding was enhanced and that both groups benefited from the interaction. The two student teachers also gained valuable know-how in doing a school-based research project as part of their initial teacher training.

**EFFECTS OF MATHEMATICAL MODELING INTERVENTION PROGRAM ON CREATIVE THINKINGABILITIES**

Talya Gilat, Miriam Amit, Ben Gurion University of the Negev (Israel)

**Abstract**

Current paper explores the effects of the model-eliciting activities (MEAs) intervention program on students’ Creative-Thinking abilities using mixed-methods realistic approach. TTCT pre- and post-tests were administered to investigate the differences between treatment and control group. Qualitative procedures were used to analyse videotapes, classroom observation and modeling products, obtained from students participating in the program. The findings indicate that the intervention
program significantly improved treatment group Creative-Thinking abilities.
Qualitative analyses generated 3 core categories—appropriateness, ‘mathematical
resourcefulness’ and inventiveness—that help us not just to identify the Creative-
Thinking abilities but also, allow us to understand how these abilities manifested
themselves at the mathematical modeling creative process that had been encouraged
through MEAs program.

Calendars in different cultures and its importance for school in a connected
world
Günter Graumann, Prof. Dr., Retired Professor of Mathematics and Didactic of
Mathematics, Faculty of Mathematics, University of Bielefeld, Universitätsstrasse
25, D-33615 Bielefeld, Germany
Abstract
With a calendar we all are confronted permanent and think of our calendar to be self-
evident. But in our global connected world we also hear from other calendars or
rhythms, especially in the context of religion. So it is good for children at school to
get to know about the background of calendars as well as to fight with problems
within the field of calendars.
First of all we have to pick up (in books or in the internet) some knowledge about
astronomical facts and the origin of different calendars whereat we can see how the
problem to bring times into special rhythms of whole numbers was managed in
history and how we can present any rational number in a rhythm of whole numbers.
Secondly we can compute with the Islamic calendar which is a pure moon-calendar
and find out why and in which way the Islamic feasts move in our solar calendar.
Furthermore we will discuss the Christian festivities and its differences in
catholic/protestant churches and the Russian-orthodox church. Especially we have to
work on the problem of determining the date of Easter (the “computus ecclesius” as it
was named in the middle ages). Finally we can look at the different phases of the
moon and the angular velocity of the moon and the stars in the night as well as the
division of the whole world into time zones.

What Characterises Mathematics in the Nordic countries?
Liv Sissel Grønmo
Department of Teacher Education and School Research, University of Oslo, Norway
Abstract
The aim of this paper is to give an overview of some important issues in mathematics
in compulsory school in Norway, Sweden and Finland. The paper will discuss
differences in trends in students’ performance in these countries, as well as
similarities in what type of mathematical content they tend to emphasis. Several
analyses of data from TIMSS and PISA have pointed out that it makes sense to talk
about a Nordic profile in mathematics education that is different from profiles in other
groups of countries such as Eastern-European, Eastern-Asian and English speaking
countries. For example, daily life mathematics, to a greater extent than in a lot of
other countries, has been a driving force for curriculum changes in the Nordic
countries in the last decades. Consequences of this for students learning in
mathematics are discussed from several perspectives. Another important issue to be
discussed is possible reasons for the recent increase in students’ performance in
Norway while there has been a decrease in students’ achievement in Sweden and
Finland. Which factors may contribute to explain these differences in trends?
Students’ opportunity to learn mathematics, what types of content knowledge that are
prioritised, and school emphasis on academic performance are important factors that are discussed.

Keywords: A Nordic Profile, Trends in Achievement, School Emphasis on Academic Success (SES), Students Opportunity to Learn (OTL)

Mathematical Modeling in the Teaching of Game Theory
Ein-Ya Gura,
The Center for the Study of Rationality, The Hebrew University of Jerusalem

Abstract
Mathematical modeling is the essence of the teaching of mathematics. The problem is that most of the mathematics taught at school has almost no connection to real-life situations and therefore the mathematical modeling is quite meaningless. In this article, we outline a course in game theory we offered to Israeli high-school students in which we show how mathematics can be used to analyze real-life situations. Game theory is motivated mostly by the social sciences and

Taming Abstraction through Classification
May Hamdan, Lebanese American University, Beirut, Lebanon

Abstract
Algebra is the first course where students are expected to go beyond the learning imitative behavior patterns for mimicking the solution of large number of variations on a small number of themes or problems. In this paper I describe how I used writing portfolios in abstract algebra to help students build schemas for proofs. I chose Abstract Algebra as a vehicle because it is in this course that students encounter proofs formally, as a new genre of mathematical text. Students are requested to keep a journal where they classify over time the different proof types they come across in this class. It is hoped that with time, it is their intuition rather than their memory that would naturally direct them to the successful proof type. Completing the project successfully is some kind of confirmation that the concepts have been encapsulated and the schemas constructed. Anyway, isn’t this how mathematicians learn how to write proofs: by first mimicking and then sorting on my own, and eventually “guessing” the clever alternative?

Keywords: proofs, Didactics, mathematical reasoning, abstract algebra, portfolios, classification, journals,

Engaging Mathematics Students in an Introductory College Mathematics Course
Heidi B. Hansen, PhD, Asst. Professor of Mathematics & Computer Science, Bemidji State University, Bemidji, Minnesota, USA
Todd Frauenholtz, PhD Professor of Mathematics & Computer Science, Bemidji State University, Bemidji, Minnesota, USA

Abstract
The purpose of this paper is to describe a typical activity used in an introductory college mathematics course to engage students. Webb et al. (2009) and Hansen (2010) described the successful development of a liberal education mathematics course designed to enhance student understanding of, and success in, mathematics but do not describe a typical day in the course. Students enrolled in this liberal education mathematics course generally lack quantitative skills, motivation, and positive experiences. This paper will describe a typical class day in a highly successful course
designed for college mathematics students who may be underprepared for tertiary mathematics study.

The co-existence of mathematics and mathematics education research: An example involving sibling curves
Ansie Harding
University of Pretoria

Abstract
The paper shows how a problem stemming from teaching the topic of complex numbers in mathematics leads to expanding the mathematics involved and how the new knowledge is ploughed back into teaching, only to be discovered by a doctoral student, expanded again and then to be ploughed back, again, into enrichment of students as an action research project. The notion of sibling curves is central to this paper and gives a unique way of visualisation of, for example, the so-called “imaginary” roots of a quadratic function. The paper describes an illustrative example of how mathematics and mathematics education research ideally feed off each other and exist symbiotically.

Building Self-Efficacy for Self-Efficacy Builders: (Workshop)
Gary Harris* Tara Stevens, Mathematics and Statistics Educational Psychology
Texas Tech University Texas Tech University, Lubbock, TX USA Lubbock, TX USA

Abstract
Mathematics teacher preparation and continuing education programs in the United States (US) focus on pedagogical skills and mathematical knowledge to prepare teachers for the classroom. Although the need for such a focus is obvious, teacher training must also include knowledge of how students approach mathematical learning if teachers are going to be successful in teaching mathematics to diverse groups of students. Students’ beliefs concerning their ability to use their knowledge and skills to successfully solve mathematical problems, mathematics self-efficacy, varies with those high in self-efficacy typically outperforming those with low self-efficacy (Pajares & Kranzler, 1995). Students’ mathematics efficacy and achievement can improve when teachers provide opportunities for students to positively experience the sources of self-efficacy (Siegle & McCoach, 2007). Unfortunately, US teachers typically do not receive training in self-efficacy and, therefore, do not have a high degree of confidence in their ability to improve the self-efficacy beliefs of their students. In other words, mathematics teachers are often not efficacious efficacy builders. The purpose of the proposed workshop is to present a program that teaches teachers how to build the mathematics self-efficacy of their students through a process that also serves to build the teachers’ efficacy.

Mathematical Reality and Modelling – new problems for mathematical classes and teaching mathematics in the secondary school
Herbert Henning, Otto-von-Guericke-University Magdeburg, Germany

Abstract
Mathematical modelling and mathematics are a „Key Technology“. Mathematics is one if the core competences in developing reliable and efficient simulations for technical, economical and biological systems; thereby, mathematics found a new role as a key technology. In order to simulate any process, it is necessary to find an appropriate model for it and to create an efficient algorithm to evaluate the model. In practice, still one of the main restrictions is time: If one wants to optimize the process,
the simulation must be very fast and, therefore, model and algorithm must be looked as a whole and, together, made as efficient as possible.

What would you like to assess with this task? Matching mathematical tasks and teaching objectives.
Hodaya (Liora) Hoch & Miriam Amit
Talpiot & Orot Israel Colleges, Israel; Ben-Gurion University, Israel

Abstract
Responsibility for assessment is being transferred to teachers so that they can critique their own work and follow each student's progress. In order to succeed in this assignment, teachers must build assessment tools by themselves. This study examines the ability of 44 pre-service and 31 novice mathematics teachers in elementary school to do so, by giving them a questionnaire which requires them to find the objective behind a given task. The results show the problems in finding suitable objectives for given tasks, with no significant differences between the two groups. Eight participants were interviewed in order to get a better understanding of the participants' way of thinking. The interviews, which reveal some of the reasons for their lack of success in doing the assignment, can be divided into three main categories: Problems in content knowledge, problems in pedagogical knowledge i.e. how to determine an objective, and the unconscious impact of their presumptions.

Teaching Mathematics in a Different Connected World of the 21st Century: Computer Simulations in Mathematics Education
Ronit Hoffmann, Ronith Klein, Kibbutzim College of Education, Tel Aviv, Israel

Abstract
Mathematics educators have been emphasizing the importance of integrating technology in schools in general, and in mathematical education in particular in ways that will promote learning, understanding and motivation to study mathematics. We believe that the school curriculum should be changed by adding up to date topics and teaching them applying technology. In our presentation we will describe how we teach one topic accordingly: Area approximation under a given curve (for a desired accuracy), which we approach in a unique way, by using computer simulations and excel. So far using simulations is absent from the mathematical curriculum (in our country). As a simple example we will describe The Monte Carlo simulation to area approximation and concentrate on the computation of the area of a unit circle. Teaching this subject gives opportunity to introduce various websites for activities dealing with the number Pi for students in various levels. This can also be taught by e-learning (asynchronous or synchronous) and leads us one step forward towards teaching mathematics in a different connected world of the 21st century.

Using photo-elicitation to investigate student accounts of mathematical reasoning during whole class mathematical discussions
Jodie Hunter, Massey University

Abstract
Opportunities to engage in mathematical discourse have been a focus of reforms in recent years. However, there are few studies which focus on students’ accounts in classrooms with interactive mathematical talk as a focus of reform. The research reported in this paper focuses on student accounts of mathematical reasoning in a classroom where the teacher reformed her practice to develop collaboration and new
forms of productive talk. It highlights the shifts in student recall of mathematical reasoning and the reasoning of their peers over a school year.

**Teacher actions to facilitate productive mathematical discourse with diverse learners (Workshop)**
Dr Roberta Hunter, Massey University

**Abstract**
Developing student reasoning has become an important aspect of teaching and learning mathematics in recent times. While many teachers recognise the importance of structuring classrooms in which all students engage in mathematical reasoning achieving them is complex and challenging. In this workshop practical actions will be discussed and outlined to support teachers to enact such classrooms. These include a Communication and Participation Framework in which students are gradually scaffolded to access and use a range of mathematical practices.

**Realistic Mathematics Education in Solving Low Carbon Society Problems**
Zaleha binti Ismaila, Kavitha a/p Dayalanb, Hamidreza Kashefic, Shiau Wei Chand
a,c,dFaculty of Education, Universiti Teknologi Malaysia
bMinistry of Education Malaysia

**Abstract**
Severe problems concerning climate change leads to the emerging idea of formulation of low-carbon society (LCS). However, the awareness about low-carbon society among Malaysians is still at the infancy stage. Understanding LCS from the mathematical perspective support Realistic Mathematics Education as well as creating awareness about this global concern. This study assessed 135 secondary students’ ability in solving mathematical problems related to low-carbon society. The problems are related to recycling, Astronaut’s daily survival requirements and energy consumption. The overall results exhibited that their ability to solve mathematical problems related to LCS was at the moderate level. Besides, results also indicated that there was no significant difference between males and females in the ability to solve the problems. This study implies that students regardless of gender should be given more opportunity to solve realistic problems so as to motivate them to appreciate the importance of mathematics.

**Creativity Fostering Behavior of Mathematics Teachers through the Implementation of School Based Assessment**
Zaleha Ismail, Yudariah Mohammad Yusof, Helen Pappu, (Faculty of Education, Universiti Teknologi Malaysia Faculty of Science, Universiti Teknologi Malaysia, Ministry of Education, Malaysia).

**Abstract**
The introduction of School Based Assessment (SBA) in Malaysian schools can be seen as providing space for teachers to foster creativity in their classroom. A study was conducted to determine the level of creativity fostering behavior of mathematics teachers involved in the implementation of SBA in the mathematics classroom. Two sets of questionnaire were developed based on the work by Cropley to evaluate the teachers’ self-report and students’ perception of teachers’ behavior respectively. The respondents consist of 246 mathematics teachers and 492 year one secondary school students. The findings gave indication that the teachers showed high level of fostering creativity behavior in the teaching and learning of mathematics. The implication of
the study is that the implementation of SBA do provides opportunities for teachers to foster creative behavior in their mathematics classroom.

**Intimations of class in responses to innovative mathematics pedagogy in initial teacher education**
Colin Jackson and Hilary Povey, Sheffield Hallam University, UK

**Abstract**
This paper reports on a small scale study in mathematics subject knowledge teaching in secondary initial teacher education. A student-focused, inquiry-based pedagogy is adopted on the course. Accounts from two participants are offered and the suggestion is made that the student responses have classed dimensions.

**Developing an Understanding of Horizon Content Knowledge: Experiences from a Practice-based Approach in Norway**
Arne Jakobsen
Department of Education and Sports Science, University of Stavanger, Norway

**Abstract**
Horizon content knowledge (HCK) is one of the least understood domains of the Mathematical Knowledge for Teaching (MKT) framework. This paper reports from the Norwegian part of a research project seeking to obtain a deeper understanding on the nature and role of HCK and on how it can inform instruction. By using simulated teaching vignettes grounded in instructional episodes and interviews with teachers, prospective and practicing teachers were interviewed to understand the nature and content of their HCK better and to access and support teachers’ learning of HCK. Findings suggests that HCK seems to provide useful orientation to hearing and working with students’ ideas and that the simulated vignettes serve as a good avenue for thinking about and discussing HCK.

**Comparative study on structural organisation of Mathematics Continuous Professional Development (MCPD) in selected Sub-Saharan countries**
Zingiswa Mybert Monica Jojo, University of South Africa

**Abstract**
This paper reports on a comparative study on mathematics continuous professional development (MCPD) programs piloted in selected developed and developing Sub-Saharan countries. The study sought to examine the status of existing professional development practice and the challenges practitioners experience in the implementation of such programs in the different countries. The study was piloted in eleven countries namely, South Africa, Botswana, Namibia, Singapore, Zimbabwe, Swaziland, Poland, South Korea, Ireland, Morocco, and Tanzania. The participants in each country were teachers, principals, subject advisors, district officials, provincial officials, service providers and facilitators. Data were collected by means of questionnaires for the teachers, interviews for other participants and observations for the facilitators. Data was then analyzed and compared using both qualitative and quantitative methods. The findings of the study indicated that teachers were exposed to different professional development programs ranging from lesson reflections in South Korea and Singapore to at least cluster workshops in underdeveloped countries.

Key words: Mathematics Continuous Professional Development, pilot study, teacher content knowledge, pedagogical knowledge, South Africa, Botswana, Namibia, Singapore, Zimbabwe, Swaziland, Poland, South Korea, Ireland, Morocco, and Tanzania
Pre-service teachers' perceptions of a Mathematics specialist teacher’s role in grades 6-8 classrooms
Karen Junqueira, University of the Free State, Bloemfontein, South Africa
Kathleen T. Nolan, University of Regina, Regina, Canada

Abstract: This paper is part of a larger study focusing on the perceptions of five different stakeholder groups about the role of a specialist teacher in the teaching of Mathematics in grades 6-8. Using a research questionnaire, the perceptions of 21 pre-service Mathematics teachers, regarding whether they would consider becoming Mathematics specialist teachers (MST) and what they considered to be the benefits and shortcomings of a Mathematics specialist teacher, were obtained. It is on these perceptions—both the positive and negative sides of the spectrum relating to the use of Mathematics specialist teachers in grades 6-8—of 13 Canadian and 8 South African pre-service teachers that the paper reports. The data indicate how our pre-service teachers think about their future career and how they, even as students, take into consideration particular aspects that may benefit or hinder their teaching.

Some trends in mathematics professional development in selected developing and developed countries: an insight into post-apartheid South Africa
Prof Luckson M. Kaino, Dr Mapula G Ngoepe, Dr Moshe M Phoshoko, Dr Zingi MM Jojo, Dr Joseph Dhlamini, Ms Ronél Paulsen, Department of Mathematics Education, College of Education, University of South Africa (UNISA), SOUTH AFRICA

Abstract
This paper reports on a pilot study on professional development in mathematics in the post-apartheid era in South Africa. The study endeavoured to examine the status of existing professional development practice and the challenges practitioners experience in the implementation of such programmes. The study involved five of the nine provinces in South Africa. The population of the study was 55 and consisted of teachers, principals, subject advisors, district officials, ministry of education and service providers. Data were collected by means of a teacher questionnaire and interviews which were analysed using qualitative methods. The study found that the status of the implementation of the Mathematics Continuous Professional Development (MCPD) programmes is determined by a variety of factors such as relations between labour unions and the employer, the political legacy of the country and others. The study also established that different participating groups experienced different challenges regarding the implementation of MCPD programmes. This data was also useful in the modification of some of the research instruments.

Key words: Mathematics Continuous Professional Development (MCPD), teacher training, teacher knowledge

The important teaching material for mathematics teacher remedial education
Toshimitsu Karasawa, Yayasan Pelajaran Mara Mara Education Foundation / Universiti Kuala Lumpur

Abstract
This article, as well as offering two- and three-dimensional figures as immediately usable educational materials to teachers of mathematics from primary school right through secondary school, also provides extension ideas for university students hoping to become teachers and for teachers themselves taking part in in-service training. That is to say, the materials provided form, as a single group, a coherent system. They have been well-received as in-service training materials.
Teaching Experiments: A Vehicle for Practice-based Professional Development
Dr. Lisa Kasmer and Dr. Esther Billings, Grand Valley State University, Allendale MI 49401 USA

Abstract
Professional development is considered a vehicle to assist in developing teacher capacities; one approach for supporting teachers is through practice-based professional development where teachers engage in activities central to their daily work of teaching. In this paper we present the results of a qualitative study investigating how teachers build mathematical and pedagogical knowledge by adapting “design experiments” to a professional development context. Through the use of case studies we examine if teachers of mathematics can, and to what extent, engage in “experiments in teaching,” an iterative cycle of three main components: conjecture (posing questions and making conjectures about teaching or learning), implementation (teaching episodes are planned and taught), and analysis which guides the next teaching episode as an intentional method for improving teaching and increasing student learning.

The Measurement Properties of the APLUS Assessment of Kindergarten Mathematics Skills
Richard G. Lambert (UNC Charlotte), Chuang Wang (UNC Charlotte), Christie Martin (University of South Carolina), David K. Pugalee (UNC Charlotte)

Abstract
The purpose of this study was to examine the measurement properties of the Assessing Math Concepts (AMC) Anywhere Hiding and Ten Frame Assessment, a two part formative assessment of kindergarten mathematics skills. The intended order of item difficulty from the test authors was clear in the results when the two parts of the measure were examined separately. However, when the parts were analyzed together, the items in Part II were not consistently more difficult that the items in Part I. A distinct pattern suggests that teachers would find the feedback from this formative assessment more useful if they presented a given number to a child with the support of the manipulatives and then presented the same number to the child without the use of the manipulatives before moving on to a larger number. This strategy would encourage children to attempt a task with support until mastery with support is achieved. Then the support could be removed until mastery without support is achieved prior to advancing to the next task.

COMPONENTS OF MATHEMATICAL COMPETENCE IN MATH GRADE OF SPANISH UNIVERSITIES
Genoveva Leví
Didáctica, Educación Escolar y Didácticas Especiales, Facultad de Educación, UNED (Spain).
Eduardo Ramos
Estadística, Investigación Operativa y Cálculo Numérico, Facultad de Ciencias, UNED (Spain).
José Antonio Carrillo
Estadística, Investigación Operativa y Cálculo Numérico, Facultad de Ciencias, UNED (Spain).

Abstract
Competences formulation documents of the new degrees of Spanish universities adapted to the requirements of the EHEA are very useful tools to analyze the
formation aimed to acquiring and developing competences, pursued in these degrees. In this paper we examine the documents containing the list of specific competences for mathematics degree in several Spanish universities, to find out if they include the basic elements that set up the mathematical competence that should be developed by future mathematicians. As research methodology, we use Content Analysis to provide structure to the documentary corpus and then we analyze this structure with statistical techniques. The results show that competence documents designed by universities contain a suitable formulation of mathematical competence, and underline the interaction between its components that reveal the dual vocation of Mathematics, partly concerned about solving their own problems as a science, and partly oriented to the issues of quantification, measurement, change and uncertainty that cause preoccupation to man at any time in its history.

LATENT FACTORS IN THE FORMATION AND DEVELOPMENT OF MATHEMATICAL COMPETENCE
Genoveva Levi
Didáctica, Organización Escolar y Didácticas Especiales.
Facultad de Educación, UNED (Spain).
Eduardo Ramos
Estadística, Investigación Operativa y Cálculo Numérico,
Facultad de Ciencias, UNED (Spain).
José Antonio Carrillo
Estadística, Investigación Operativa y Cálculo Numérico,
Facultad de Ciencias, UNED (Spain).

Abstract
This paper presents some results of a study on the relationships and interactions between the various components that set up mathematical competence. The method involves the application of the statistical technique of factor analysis to a set of variables on the academic performance of students taking the subject Applied Mathematics to Social Sciences taught in the Foundation Course for access to university for students 25 years old and over at the National University of Distance Education of Spain (UNED). The results show that the mathematical knowledge that integrate the traditional curriculum are settle on various factors related differently to mathematical capabilities and attitudes, suggesting the development of innovative strategies for planning the formation and development of the mathematical competence.

Conceptual Understanding and Computational Fluency
Cheryl A. Lubinski, JoAnn Cady & Albert D. Otto

Abstract
In this paper we present the findings from a study on how a course on conceptual understanding influences students’ computational fluency on a quiz consisting of 15 calculations. The focus of our research was on the strategies used by the students in a freshmen college course designed for elementary education majors. Findings suggest that focusing on conceptual understanding did not compromise students’ computational fluency skills. Preliminary findings suggest that students can develop higher-level computational strategies without a focus on teaching those strategies when conceptual understanding is emphasized.

Generalization questions at early stages: the importance of the theory of mathematics education for teachers and pupils (Workshop)
Nicolina A. Malara, Giancarlo Navarra
Abstract
We discuss the introduction of early algebra in primary school, stressing the role of the theory of mathematics education for a reconstruction of the teachers’ knowledge, awareness, beliefs and behaviors and to promote the teaching of arithmetic in a pre-algebraic perspective. We present some excerpts of classroom episodes, from experimentations carried out in collaboration with teachers, which testify the influence of new ways of teaching on the pupils’ performance.

USING HISTORY IN TEACHING
Pieter Maritz, University of Stellenbosch, South Africa

Abstract
This talk deals with attempts by the author to employ a combination of history of mathematics and aspects of cultural importance to elucidate the teaching of mathematics. The point of departure is that mathematics is created by human beings. Some of these human beings found themselves in invidious positions because of their political, cultural or religious agendas and affiliations. Students should be made aware of the lifes of some of the people behind the mathematical discoveries. No case studies were made to investigate outcomes of linking mathematics history, mathematics education and school practices. The aim was merely to teach so that students see and appreciate the nature, role, and fascination of mathematics; so that students know that people are still creating mathematics; and so that students can also have the thrill of discovery and invention.

TEACHER INSTRUCTION INFORMED BY STUDENTS’ MATHEMATICAL WRITING
Christie Martin, Ph.D., University of South Carolina, Drew Polly, Ph.D., Chuang Wang Ph.D., Richard Lambert Ph.D., University of North Carolina

Abstract
In this study, we examine how using a writer’s workshop model in mathematics creates a space for students to write and reflect on their mathematical thinking and problem solving. We present the analysis of students’ writing and the ways in which the writing informed the teacher’s instructional decisions. The study spanned six weeks and included 18 implementations of an adapted version of Writers’ Workshop in a fourth grade mathematics class. On a biweekly basis, the data were reviewed and changes made to the model. The students’ writing prompted conferencing questions, assisted in grouping decisions, and influenced decision as to whether to move to a higher level of instruction.

40 years after the New Math movement of school mathematics - what we should learn from the failure
Soshi Matsunami
(Dept. of Math., Graduate School of Science and Technology, Meiji University, JAPAN, ce46214@meiji.ac.jp)
Ryosuke Nagaoka
(Dept. of Math., Faculty of Science and Technology, Meiji University, JAPAN, nagaoka@math.meiji.ac.jp)

Abstract: The New Math movement in 1970's should be re-evaluated in the light of 40 years's experience of the decay of mathematics Education in Japan. The most important points are examined to realize another but truly innovative reformation of mathematics education and some ideas with which we are now working on future
mathematics teachers are discussed. A few principal viewpoints will be proposed to make a “new modernization” a fruitful innovation of school mathematics education.

Suggested Future Policies for Teaching and Learning Mathematics In Elementary Grades
Fayez M. Mina, MA PhD C. Math FIMA,FIBA, Emeritus Professor, Faculty of Education, Ain Shams University, Roxy, Heliopolis, Cairo, Egypt

Abstract
The paper started with a general look at teaching and learning mathematics in elementary grades, where mathematics syllabuses have almost the same content, and rote learning is dominating in many countries. Pupils relations with the study of mathematics become bad, especially when they are asked to “memorize” the multiplication table and perform “long division” problems. Some suggested future policies for teaching and learning mathematics in elementary grades are derived from the suggested strategic goal which is “enabling pupils to behave as researches”. These policies varied from dealing with knowledge in integrated contexts, to the use of technology and employing the multiple intelligences theory, to teaching mathematics and introducing changes in both methods of teaching and means of evaluation. The paper is concluded by some remarks by which the suggested policies are clarified and explained, side by side with referring to their applicability in different countries.

The Effects of Different Virtual Manipulatives for Second Graders’ Mathematics Learning in the Touch-Screen Environment
Patricia S. Moyer-Packenham, Utah State University, Arla Westenskow, Jessica F. Shumway, Emma Bullock, Stephen I. Tucker, Katie L. Anderson-Pence, Jennifer Boyer-Thurgood, Cathy Maahs-Fladung, Juergen Symanzik, Salif Mahamane, Beth MacDonald, & Kerry Jordan, The Virtual Manipulatives Research Group at Utah State University

Abstract
This study examined second-grade children’s interactions with six virtual manipulative mathematics apps on the iPad. Following 30-40 minute interviews where children interacted individually with the apps under the guidance of an interviewer, pre and post assessments revealed statistically significant differences in second graders performance and efficiency using one series of apps to learn skip counting concepts, but no significant differences when using a series of apps to learn place value concepts. Results are discussed in terms of differences among the virtual manipulative apps that produced differing outcomes for children.

A Critical Review of Research in Self-Efficacy in Mathematics Education
Priscilla Murphy, MIT, Auckland, Leigh Wood, Macquarie University, Sydney, Leanne Carter, Macquarie University, Sydney.

Abstract
This review examines the role of self-efficacy and its relation to learning constructs within the context of tertiary mathematics education. Using a research software (NVivo 10), we conducted a content analyses of sixteen research articles in mathematics education. Most quantitative findings showed that personal efficacy was related to mathematical performances and study strategies (deep and surface learning) and prior mathematical experiences. However, qualitative studies theorised self-efficacy to Bandura’s (1997) four sources of self-efficacy (mastery, vicarious, social
persuasion and physiological state). Based on the research findings, we discussed the potential strengths and pitfalls of the research methods. Finally, for future research, we propose a conceptual framework, linking relationships between the motivational construct, learning variables and mathematical performances (grades).

PROBLEM-BASED LEARNING IN SCHOOLS
Najihah binti Mustaffa, Zaleha binti Ismail, Faculty of Education, University Teknologi Malaysia, 81310, Skudai, Johor, Malaysia

Abstract
Problem-Based Learning is a pedagogical and instructional approach towards holistic learning by demand thinking and intentional connections using relevant and meaningful real life. Problem-Based Learning promotes problems as a process of learning consists of reinforcement of existing knowledge integrate with new content acquisition and new information towards problem resolution. Originally problem based learning has been implemented in medical schools and since then widely spread to higher institutions. Does Problem-Based Learning is appropriate to be implemented in primary and secondary schools. This meta-analysis will study on the impact of implementation of Problem-Based Learning in schools. Initial analysis shows that Problem-Based Learning played a significant role in preparing teamwork and problem solving among schools students.

Key words: Problem-Based Learning, schools, teamwork, problem solving

On mathematics teaching in Finland
Marjatta Näätänen Doc., Liisa Näveri Ph.D, University of Helsinki

Abstract
Finnish math teaching has been highly praised due to the PISA survey, but Finnish mathematicians have criticized the news coverage of the success of the PISA-results. Recent studies show the deterioration of the level of math skills and claim that PISA-type problem solving is not the solution to basis for theoretical advancement. Among others the results of Näveri show that building a concrete model is necessary. In year 2000 an experiment to teach following the Hungarian Varga-Neményi -method was introduced in some voluntary primary Finnish schools. This method advances from concrete to abstract. In the presentation, details will be discussed.

How Do We Plant Seeds of Algebra in the Elementary Grades?
Monica Neagoy, Ph.D., Independent Scholar/International Consultant, MN Mathematics Consulting Services

Abstract
In the United States, The curriculum standards (NCTM, 2000; CCSSM, 2010) insist on teachers cultivating algebraic notions and ways of thinking from the very early grades. One reason is because the children of today, or leaders of tomorrow, will live in a world with technological tools whose capabilities exceed our imagination. This reality gives us pause and begs questions such as, “What is our purpose in teaching operations when our tools already compute more quickly, more efficiently, and more correctly than we can?” The bar has therefore been raised for elementary teachers and the greater purpose is algebraic thinking in particular and deeper mathematical thinking in general. But what does it really mean to “do algebra” in the early grades? How can teachers learn to teach elementary mathematics topics in ways that bring out their algebraic character? What resources do teachers, teacher coaches and leaders have that empower them to in turn empower their students with a strong
foundation for algebra? The speaker will answer these questions by sharing the research and implementation of concrete and engaging examples drawn from her book series—Planting the Seeds of Algebra (2012; fall 2014).

The voice of the teachers about Mathematics Continuous Professional Development
Mapula G Ngoepe
Department of Mathematics Education
College of education
P.O Box 392, Pretoria, 0003

ABSTRACT
This paper reports a pilot case study on the voices of mathematics teachers on continuous professional development (MCDP) in some provinces in South Africa and their experiences of it. The exploratory research design involved a questionnaire that was piloted in 5 provinces. The pilot presented in this paper survey of mathematics teachers’ in three provinces. The teachers were asked to voice their opinion with regard to MCDP in their communities of practice. Content analysis was used to analyse the data. Themes that resulted from the analysis were nine and are with respect to meaning of MCDP programmes, topics covered, impact on classroom practice, financial support and adequacy, benefits, challenges of implementation and suggestion for improving MCDP. The voices will be captured in the written words of the teachers. The insights gained from the research will help in designing professional development programmes that address the needs of the teachers.

History of Mathematics and Mathematics Education - A reflective study on the possibility of History of mathematics to be implemented as teaching material in upper secondary level
Sho Niitsuma (Dept. of Math., Graduate School of Science and Technology, Meiji University, JAPAN, ce36205@meiji.ac.jp)
Ryosuke Nagaoka (Dept. of Math., Faculty of Science and Technology, Meiji University, JAPAN, rnagaoka@math.meiji.ac.jp)

Abstract:
Many discussions and papers have been devoted on the possibility of history of mathematics to be integrated in mathematics education. But as far as I observe in a Far East country, the general situation of mathematics education has not been largely reformed by taking historico-cultural approach in textbooks, and in teaching materials. To realize really efficient use of the history of mathematics, a critical look at the possibilities as well as the difficulties is needed.

Studying the intersections of real, virtual and 'best practices' in becoming a mathematics teacher through professional learning communities
Kathleen T. Nolan, University of Regina, Regina, Canada

Abstract
In traditional teacher education field experiences, working as part of the triad of intern (student teacher), cooperating (mentor) teacher, and university faculty advisor can be a challenge for all involved. The intern often becomes disconnected from the university as she/he embarks on the 'practical' learning in the school classroom, while the faculty advisor feels like an outsider and token aspect of the intern's professional development in their process of becoming a teacher. In the research being discussed in this presentation, the faculty advisor (also the researcher) created a digitally-
enhanced internship experience, featuring a teacher-intern-faculty advisor (TIFA)
learning community. Over a four month period (the internship semester), this
learning community consisted of three (3) TIFA triads who engaged in several face-
to-face lesson study sessions, web-based conferences sessions, and collaborative
video analysis of teaching episodes. The research goals were two-fold: (1) to
understand more about 'best practices' (i.e. meaningful and sustainable practices based
in blended learning environments) for teacher education field experiences and
becoming a mathematics teacher, and (2) to critique the network of relations and
discursive practices that support (and (re)produce) traditional practices in teacher
education programs.

The Applications of Augmented Reality Technologies in Mathematics Education
Mehryar Nooriafshar, University of Southern Queensland, Toowoomba, Australia
Darius Nooriafshar, COMTEL, Australia

Abstract
Recent research in the area of multimedia conducted by the authors in Australia,
Japan and North America has re-confirmed the importance and effectiveness of
visual features in teaching and learning materials. According to the findings, the
visual aspects and interaction with the multimedia systems are the most preferred
features amongst the surveyed students. In all of these studies, the surveyed
students have also indicated that the visual features play a very important role in
understanding the concepts. Based on these findings, the authors have embarked
on an investigation to determine the practical and innovative uses of the
technologies associated with augmented reality. A very typical augmented reality
product is Google Glass. Hence, this paper has initiated a study on the possible
contributions this amazing device can make to mathematics education. It has
been shown that Google Glass can assist learners to access and share information,
connect and engage in discussions with others by utilising a more human-like
interface.

Key words: Google Glass, Augmented Reality, Mathematics, Education

The Relationship Between Learning Styles and Achievement on Linear Algebra
Course
Nevin ORHUN, Anadolu University Science Faculty, Department of Mathematics
26470, Eskisehir, Turkey

Abstract
This study examines the relationship between learning styles of students and their
success on the linear algebra course. Besides it has been examined that whether one or
more learning styles are dominant among the group members or not. In this study, the
categorization of students’ learning style score was defined. The given method for
calculating of learning style score was developed by the author. The purpose of this
study is to raise the success level of the students on a linear algebra course. Therefore
it has been analyzed whether the success depends on the way of learning style or not.
The data which has been used in this paper is gathered from David Kolb’s learning
styles model and the students’ grades on linear algebra course. Consequently; base on
the findings, a significant difference has been found among students’ learning styles
and their performance on the linear algebra course. From the relationship between the
students’ learning styles and their performance, it was found that convergers
performed better than the others.

Keywords: Learning Styles, Linear Algebra, Achievement, Teaching Strategy,
Mathematics Education.
WORDS OR CONCEPTS? STUDENTS’ UNDERSTANDING OF ‘RIGHT ANGLE’
NICK VINCENT OTUMA

Abstract
This paper examines form two students’ understanding of ‘right angle’, words commonly used in secondary school mathematics syllabus. 48 students participated in this study. Participants were asked to identify a right angle among four plane figures given. Past research has indicated that words have specific meaning in mathematics but their meanings in other contexts may be diverse and pose a challenge to students learning mathematics. Results of this research suggested that many students have limited understanding of a right angle. This study recommends teaching of mathematics vocabulary together with symbolic notations to facilitate conceptual understanding.

Providing Student Support for Gaining Early Awareness and Readiness for Undergraduate Programs (GEAR UP)
Eric Packenham, Utah State University

Abstract
The mission of the GEAR UP program is to significantly increase the number of low-income students who are prepared to enter and succeed in postsecondary education. At Utah State University (USU), the GEAR UP Program is called: Science Technology Arithmetic Reading Students (STARS!) and serves over 3000 students. The program is currently in its second year of a seven-year GEAR UP grant. This paper describes student services, student progress and overall project progress that have led to students’ success in the program.

Peer Interaction for Improving High Students’ Argumentation Ability in Mathematics Problem Solving: Results from a Study
Angela Pesci, Department of Mathematics, University of Pavia, Italy

Abstract
This contribution presents the main results obtained from a study based on a didactical experience with 12 to 13 years old pupils. The objective of the study was to find out whether argumentation competence in skilled math students would improve following peer to peer class activities. The research, conducted on a group of 8 pupils, has requested the choice of adequate mathematical problems for the purpose as well as the choice of variables to focus on. We underline the positive results obtained but also the limits of this experience and make some suggestions for further study.

Evolution From e-learning materials to the i-Textbooks in slovenia
Igor Pesek¹,4, Blaž Zmazek¹,5, Darko Drakulić², Eva Zmazek³
¹Faculty of Natural Science and Mathematics, University of Maribor, University of Maribor, ²Faculty of Philosophy, University of East Sarajevo, ³Gimnazija Ptuj

Abstract
This paper presents the evolution of e-materials from the first implementations in the early ages of the Internet to the recent results in the development of i-textbooks. Revolutionary breakthrough in the field of using e-materials in e-textbooks and later evolution to the latest i-textbooks is described in this work.

Keywords: interactivity, textbooks, e-textbook, i-textbook, licenses
Mathematics in a Connected World
Anne Porter
Abstract
The issues confronting mathematics teachers remain as they have been for many years. How do you engage students who do not want to learn mathematics? How do you teach to students with varying abilities? How do you convey the relevance of mathematics? How do you engage students from different socioeconomic and ethnic groups? The questions all present as challenges. In a connected world there are many more options for addressing such challenges. The ease of creating and/or accessing learning resources in a connected world has enabled possibilities such as MOOCs, flipped classrooms, online learning, learning support programs and headstart programs. With such opportunities other issues arise, such as how to develop appropriate learning designs that minimize cognitive load and optimize learning, how to provide feedback and how to provide for deep and meaningful learning.

Transformative learning through educative assessment: one student's experience of a learning journal
Hilary Povey
Abstract
It is now widely understood that assessment practices have a key influence on learning. Summative assessment tends to have a damaging effect overall and in particular on learners' self-awareness and deep engagement. Both these in turn produce a deleterious effect on attainment. This research concerns the use of learning journals in a university mathematics module, taken by secondary initial teacher education students, for the assessment of learning (summative), for learning (formative) and as learning, developing further the concept of educative assessment. Using a narrative approach to analysis, this paper focuses on the experiences of one of the course participants for whom engagement with the learning journal radically changed her view of the subject - she came to see it as an open and creative subject - and her view of herself as a learner. The implications for teaching and learning and for assessment practices are considered.

Who Owns the Learning, and can the Learner be the teacher?
Dena Reddan, Leader of Learning and Teaching, St. Therese School, Torquay
Abstract
The following paper follows the journey of St. Therese School, Torquay, Australia, in exploring the improvement of student learning through an inquiry into the ownership of learning. Students were encouraged to direct their own learning through the use of self-assessment, using a variety of tools. This assessment then helped them determine “where to next for me”. The use of learning intentions and success criteria, as well as exemplars to model high expectations, aided them in clarifying direction. The curriculum was exposed to the students, with a focus on learning as a journey. Parents of the students were kept in touch with their child’s learning via ICT tools as well as personal meetings with their child. The focus on student–led workshops, where students teach each other, have also been used as a tool for learning ownership. This workshop aims to share the continuing journey of high expectations, high student engagement and most of all students articulating a love of learning!
Connecting through mathematics: on non-specialists’ mathematics teacher identity
Melissa Rodd and Cosette Crisan, Institute of Education, University of London

Abstract
In the greater London area there is a shortage of mathematics teachers and so there are teachers qualified in subjects other than mathematics who contribute to the teaching mathematics in secondary school (to pupils of ages 11-16 years). To address these teachers lack of subject-specific training, the UK government has funded various in-service subject knowledge courses. This paper reports on research on teacher identity that has taken place along-side these courses over the past five years by some of the tutors on these courses at the authors’ institution. The central query concerns how course-participants’ learning of secondary school mathematical content impacts on their identity as a teacher. Data for the teacher-educator practitioner research reported in this paper has come from course-participants’ class-work, assignments and interviews. The theoretical framework employed for analysis has been adapted from Wenger’s (1998) *Communities of Practice*. In terms of Wenger’s modes of belonging to a community of practice, analysis suggests that imagination is a less secure mode of belonging to a mathematics teacher community of practice than engagement with school mathematics or alignment with mathematical practices.

Formative Mathematics Assessment: Supporting Learning and Understanding for Teachers and Students
Angélique Seifert, David K. Pugalee, Chuang Wang, Richard Lambert, Christie Martin

Abstract
This paper reports on the effectiveness of a professional development project *Assessment Practices to Support Mathematics Learning and Understanding for Students (APLUS)*. The project assists the implementation of an assessment model in grades K-3, with the accent on providing teachers in K-2 with the skills and knowledge to effectively use *Assessing Math Concepts* (Richardson, 1998). Though no statistically significant differences between the student treatment group and student control group were revealed, the average performance for classroom and school were found to have significant impacts on student performance and the connection between performance and time passed from the beginning to the end of the use of the *Assessing Math Concepts* assessments.

Educational Drama (EduRama): An innovative Pedagogical Model for Enhancing Learners’ Interest in Mathematics
Nalin Sharda, Victoria University, Australia

Abstract
In this paper we explore how educational drama (EduRama) can be used to enhance learners’ interest in mathematics. ‘Arcadia’ a play by Tom Stoppard, and ‘Fermat’s Last Tango’ a musical by Joanne Sydney Lessner, are taken as examples of creative works that have been recognized for their ability to introduce mathematical concepts. The main thesis of this paper is that we can enhance the interest of learners in mathematics by introducing mathematical concepts through drama and other creative works. One such EduRama, ‘To Log or Not-to-Log’, is included to demonstrate the concepts underpinning this innovative pedagogical model.
Tracy J. Shields, 955 Oliver Road, Lakehead University, Faculty of Education, Thunder Bay, Ontario, Canada P7B 5E1

Abstract
Meeting the mathematical needs of a global world with an indeterminate future poses diverse and distinctive problems of the mathematics programs required to ready students for empowering futures. NCTM’s (2000) principles were adopted by the Ontario Ministry of Education (2005) and have infiltrated the Ontario mathematics curriculum for the past thirteen years. In this article I will be challenging mathematics educators to re-evaluate the historical roots of conceptual based mathematics principles including that of the derivation of the area formula of the circle using triangular like approximations in Dissection Motion Operations (DMO). The movement toward reform based mathematics classrooms finds its needs grounded in concerns about procedural-based learning for a new world and in doing so, needs to be mindful and dutiful that due credit is given to Indigenous cultures which we now know have made major contributions to the body of mathematics. This article is an appeal to the mathematics community to begin to invite Indigenous peoples around the world to explore and enjoy their own sense of cultural connection to the mathematics they are taught in school, so that their attitudes toward the study of math concepts may adjust to embrace a renewed sense of belonging and empowerment.

Formation Research Competences of Future Teachers of Mathematics Using Technology of Portfolio and Virtual environment Moodle
Skornyakova Anna, Master Degree, Perm State Humanitarian Pedagogical University, Sibirskaya, 24, Perm, Russia

Abstract
In article proposes the approach to formation the research competences of students in Pedagogical University using environment Moodle and educational portfolio by the example teaching of mathematics.

Aiding Transition from Secondary School to Entry-level College Mathematics
Dr. William R. Speer, Director, Mathematics Learning Center, Professor of Mathematics Education, University of Nevada Las Vegas

Abstract
Many states in the United States have adopted a set of Common Core State Standards (or some close-knit variation to the CCSS). Most often these standards are not viewed as “exit standards” but instead are described as college- and career-readiness standards. As these standards evolve through implementation and use, perceptions of “academic preparedness” may also mature with stakeholder expectations. The changing landscape of assessments in the K-12 is a reflection of the rethinking taking place in regards to assessing as an endpoint versus seeing it as a starting point. Of course, we are interested in whether students have mastered a particular content set or objectives, but we are also concerned with their preparedness to go on in their explorations of formal and informal learning. The discussion in the US today is particularly targeted toward college and career readiness in mathematics and English/Language Arts and what such scores mean relative to students' academic preparedness for college. Higher education leaders should play an active role in this discourse as they will be direct beneficiaries if students arrive on campuses prepared
to meet the demands they will face. This session offers a case study (of sorts) of one particular state’s multi-pronged approach to assisting in this transition from secondary school to college and careers with a particular emphasis on retention and progression in the “first years” of university life and on to completion of a formal bachelor’s degree.

**Preliminaries for a first year course on Modelling**
Kerri Spooner, AUT University

**Abstract**
I will present the results of my 2012 research project on outcomes achieved by secondary school students who were given an authentic mathematical modelling experience. This research has impact on the potential understanding of secondary school students on modelling entering university. I will present my findings and their potential impact on a first year modelling course. I will discuss what aspects of the modelling experience were possible at secondary school and therefore should be easily achievable at undergraduate level; what things students enjoyed about the experience and therefore useful to include; and what things they struggled with, providing a sign that these things need good instruction and relevant time.

Keywords: mathematical modelling, transition secondary to tertiary.

**Whole-class discussion in the mathematics classroom: Analyzing a multimedia case in teacher education**
Rosa Tomás Ferreira¹, Hélia Oliveira², Márcia Cyrino³
¹ Faculdade de Ciências da Universidade do Porto & CMUP, Portugal, ² Instituto de Educação da Universidade de Lisboa, Portugal, ³ Universidade Estadual de Londrina, Brazil

**Abstract.**
This study addresses the use of a multimedia case in teacher education by mathematics pre-service teachers. Focusing on the whole-class discussion phase of an inquiry-based lesson in 7th grade, we aim to understand how pre-service teachers analyze an episode of this phase of the lesson regarding the teacher’s actions and role in conducting the discussion. We analyze the participants’ written productions while exploring the case. Data reveal that pre-service teachers can identify several central actions of the teacher in the case, both in promoting students’ mathematical learning and in managing their interactions. Data also show some understanding of the role of teacher’s questioning in the interpretation of those actions. Results suggest some issues for future research and for the exploration of the case in contexts of teacher education and professional development.

**Preparing Teachers for Common Core State Standards-Based Instruction of Mathematics in California**
Agnes Tuska and Rajee Amarasinghe, Department of Mathematics, California State University, Fresno, 5245 N. Backer Avenue, MS PB 108, Fresno CA 93740-8001

**Abstract**
Teachers, administrators, and teacher educators work closely in California on the effective implementation of the Common Core State Standards, the standards that provide so far the best opportunity for students to live up to the mathematics content-related expectations towards the workforce in the 21st century. While the required changes have attracted significant corporate business interest, promising quick fixes and expecting large profits, many teacher educators work on developing long-term,
collaborative support for teachers in order to make the process of implementation successful. This paper gives two examples of such collaborations: one related to the use of the GeoGebra software, and another about the use of demonstration classes as integral parts of workshops for teachers.

**Using the TIMSS results for improving mathematics learning**
Ariana-Stanca Văcărețu, MA, Mathematics teacher, Romanian Reading and Writing for Critical Thinking Association, Cluj-Napoca, Romania

**Abstract**
Trends in International Mathematics and Science Study (TIMSS) is a comparative study which measures trends in mathematics and science achievements of fourth and eighth graders. Romania has participated with the eighth graders in all five assessments (1995, 1999, 2003, 2007, 2011) and TIMSS reports have provided relevant information on both mathematics and science achievement trends and key curricular, instructional, and resource-related factors that can impact the teaching and learning process (Mullis et al., 2012). However, prior to 2011, Romanian policymakers, administrators, teachers and researchers didn’t use the TIMSS reports for improving the Romanian educational system. As teachers have some freedom in designing their instructional approach, we consider that if they are aware of the TIMSS evaluation and results they can use these results for improving learning outcomes. This paper presents how mathematics teachers may use the results of the TIMSS evaluation(s) for improving their teaching practices and their students’ learning outcomes. We will analyze an eighth grade TIMSS mathematics item and percent correct statistics for the item, identify students’ related misconceptions and provide examples of learning activities for addressing students’ misconceptions by preventing or correcting them.

**CREATIVITY THROUGH CHALLENGING LEARNING TASKS**
Isabel Vale, Ana Barbosa
School of Education of the Polytechnic Institute of Viana do Castelo, Portugal

**Abstract**
Tasks proposed to students influence greatly what they learn. These are of great importance, especially if they lead to an understanding of structural and mathematical concepts and encourage fluency, flexibility and originality as components of creative thinking. So, it is important to understand the performance of future teachers in problem solving and posing tasks that foster creativity and identify tasks that can help achieve this goal. So we developed a study, still ongoing, in the context of initial teacher education, that seeks to identify math tasks to enhance students’ creativity. We used a qualitative approach and data was collected in a holistic, descriptive and interpretative way. Our preliminary findings, based on future teachers productions, indicate that the tasks used, identify some dimensions of creativity in future teachers.

**Investigating the behaviour of the FGH predator-prey model using technology**
Quay van der Hoff, Johanna C. Greeff, Temple H. Fay, (Department of Mathematics and Applied Mathematics, University of Pretoria, Private Bag Pretoria 0002 South Africa, Department of Mathematics and Statistics, Tshwane University of Technology, Private Bag X680 Pretoria 0001 South Africa)

**Abstract**
The FayGreeffHoff predator-prey model contains self-limiting factors for both predator and prey and as such, all solutions are bounded within the population.
quadrant. In most cases there is but a single critical value, an attracting spiral point suggesting a stable population pair or an unstable node, resulting in a unique limit cycle. The critical values of the system are related to the roots of a cubic polynomial and it is only when the cubic has multiple positive roots that the system becomes unstable. Thus the analysis of equilibria comes down to investigating a cubic polynomial. The level of mathematics and technology required make it ideal for inclusion in a senior-level or introductory graduate-level ODE course. Interesting phenomena can be observed with the use of a Computer Algebra System, such as Mathematica.

Problem Solving as a Tool for Learning Mathematics (Workshop)
Dr. Natalya Vinogradova

Abstract
Are you looking for rich mathematical problems? One such problem will be discussed during the workshop. The problem is suitable for mathematics learners familiar with middle school ideas. That is not to say that it is easily solvable by the typical middle school student! This problem has been presented by the leader of the workshop many times to various audiences, including mathematics teachers of different grades. Not being widely published, it has been new to all participants so far. Come to experience the challenge and joy of authentic problem solving!

Teacher Use of Formative Assessment and its Relationship to Primary Students’ Mathematical Skills
Chuang Wang, Christie Martin, Richard G. Lambert, David K. Pugalee, University of North Carolina at Charlotte

Abstract
This is an evaluation of a professional development intervention to assist teachers in developing the skills, knowledge and resources needed to assess students’ number sense understanding formatively and use that data to shape future instruction. Participants in this study are 228 teachers with 3666 K-2 students in 51 schools in North Carolina of the United States. A four-level hierarchical linear model with the first level representing the monthly linear growth of students’ mathematical skills assessed by the Hiding and Ten Frame assessment. The results of the linear growth models suggest that teachers are able to identify students who need more assistance in learning mathematics, give them more frequent assessments, and evaluate their ongoing processes. We also found that the number of assessment that students received from the teacher had a positive relationship to the monthly growth rate of the student’s mathematical skills. These findings suggest that teachers are encouraged to assess the students more frequently not only to have a better understanding of the student’s progress of learning but also to make the students aware of their own progress. This awareness might motivate the students to learn and make faster progress in learning.
Cute Drawings? What Students’ Fractional Representations Reveal About Their Whole Number Bias
Arla Westenskow, Patricia S. Moyer-Packenham, Katie L. Anderson-Pence, Jessica F. Shumway, Kerry Jordan, The Virtual Manipulatives Research Group at Utah State University

Abstract
This study examined 371 third and fourth grade students’ fraction pictorial representations for evidence of whole number bias. Students exhibited difficulties in developing and using fractional representations. Four areas of whole number bias were identified in the students’ representations; naming fractions, partitioning, comparing fractions, and developing equivalence.

Using Blended Learning for the teaching of High School Mathematics.
Bruce White University of South Australia Bruce.White@unisa.edu.au Alan Barnes University of South Australia Mike Lawson Flinders University

Abstract
The use of blended learning for teaching mathematics in South Australian secondary schools is not widespread. This paper reports on a study at a large suburban high school in South Australia that has recently made a significant effort to develop an online presence for most of its subjects (including mathematics) to support student learning. The blended learning approach was supported via a significant professional learning program at the school around Moodle which was the learning management system used by the school. In the study over three consecutive years the students were asked to indicate what they thought about how useful was the use of Moodle and to comment on how it could be improved via an online survey with over 70% of the students responding each year. The students were quite positive about the use of Moodle with the year 8 and year 12 students being the most positive. The student text responses indicated that they were using it as a means of accessing materials with senior year’s students commenting how they found it very useful for revision when the mathematics teachers uploaded the Interactive Whiteboard recordings. They also thought teachers were more organised as a result of using Moodle. The students commented on how the use of blended learning within the school could be improved; that they wanted the teachers to still “teach”, to increase the interaction on the moodle site and to make sure that the material was well structured.

TRANSCENDING MATHEMATICAL BOUNDARIES: THE CASE OF CRYPTOLOGY
Kalvin Whittles, Cape Peninsula University of Technology

Abstract
This paper explores the question on how new content could be introduced into a school mathematics curriculum. Cryptology, a topic in mathematics, is the chosen topic for this study. The study, pursued in the discipline of mathematics education, starts out in mathematics and ends up in a school mathematics classroom. Mathematics education served as a broad framework for the study informing the choice of theoretical framework and methodology. Realistic mathematics education and didactical transposition are used as theoretical frameworks as an underpinning for the design of instructional materials for grade 10 learners for school mathematics. Firstly, realistic mathematics education is used as a framework for its didactical philosophy on mathematical learning and teaching as well as the design of instructional materials. Secondly, the framework of didactical transposition is for the
processes by which mathematical topics move from their source of origin in mathematics and in history to various places of teaching, namely a grade 10 school mathematics classroom. The main finding points to the implementation of teaching experiments as forms of a mini-curriculum that moves away from the declarative notion of curriculum implementation and points more to the mini-curriculum as an outcome of the proposed design procedure.

Using Problem Solving to Transform Students’ Algebraic Thinking
Will Windsor & George Booker

Abstract
The purpose of this paper is to demonstrate how children can develop an algebraic perspective of mathematics, by focusing on a broader conceptualisation of algebra based on a problem solving. The potential benefit in developing algebraic thinking using a problem solving approach is that it may broaden and develop students’ mathematical

University Students’ Limited Knowledge of Limits – from Calculus through Differential Equations
Alan Zollman, Mathematical Sciences Department, Northern Illinois University
DeKalb, Illinois, USA

Abstract
Calculus is the entry-level course for studying higher-level mathematics necessary for engineering, economics, statistics, and the natural sciences (Zollman, in press). The concept of limit is the basis of calculus-based mathematics and is essential for advanced mathematical thinking, both in educational and occupational environments. Research recognizes that many students struggle with limits (Artigue, 1992; Artigue, Batanero & Kent, 2007; Cappetta, 2007; Cappetta & Zollman, 2009; Cornu, 1981, 1991; Davis & Vinner, 1986; Juter, 2005, 2007; Li & Tall, 1993; Monaghan, Sun & Tall, 1994; Oehrtman, 2009; Robert, 1982; Sierpinska, 1987; Tall 1992; Tall & Vinner, 1981; Williams, 1991). Based upon these studies, recent research (Beynon & Zollman, in review; Cappetta & Zollman, 2013; McCombs, 2014; Patel, 2013; Patel, McCombs & Zollman, 2014; Wangle, 2013) identifies specific student difficulties with limits. This paper is a synopsis of these recent research findings and gives suggestions on instructional approaches to alleviate them.