All Abstracts

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Abstract for 21784

Sketching Graph of Function using Software

Authors: VLADIMIR NODELMAN
Affiliations: Holon Institute of Technology

One of the typical tasks in the study of functions is sketching of their graphs. The acquired skills, as well as the ability to read graphs, are notably useful in the later life.
The software used in teaching mathematics automatically builds ready-made graphs. While studying sketching these graphs are unacceptable. Traditionally, sketching is done by hand on paper. Nowadays (rarely) this can be done on a computer monitor as a freehand drawing. The resulting curves are very approximate and rough.
This paper illustrates the method of sketching graphs with intensive use of software. In general, the types of student's activities do not depend on the specifics of functions. They explore a common model with the help of author's non-profit software "VisuMatica".
This model includes a function f(x) with a hidden graph and the ability to visualize its characteristic properties:

- Intervals of sign constancy,
- Discontinuities,
- Local max/min,
- Supremum/infimum,
- Critical points,
- Asymptotes,
- Domain/Range,
- Inflection points.

Using this show, the student builds a sketch of the graph (one or more of its branches), by setting control points. The program connects them with appropriate smooth curves. These curves can be edited by dragging, exact locating, adding and removing control points. If one suspects a function periodicity, it is enough to sketch a curve at a proper interval and select the option "replicate along the X-axis".
The result is checked by unhiding the graph of f(x) and comparing it with the constructed sketch.
The model is universal: to build a sketch of a graph of another function, it is enough to redefine f(x) and the whole show (except of old sketch) rebuilds automatically.

Abstract for 21785

Multiple-choice questions in Mathematics: automatic generation, revisited

Authors: Kosaku Nagasaka
Affiliations: Kobe University

The multiple-choice question is one of very common assessment tools in the e-learning environment. Especially in mathematics learning, the multiple-choice question is used mainly for assessing lower-level cognitive processing (e.g. definitions, simple computations and so on), and there are not so many known studies on the multiple-choice question in mathematics learning: benefit, guiding principle, automatic question generation and so on.
In this paper, we show our guiding principle, our whole system based on Moodle and Python (with Jupyter notebook), and some examples of automatic question generators in linear algebra and fundamental calculus.

Abstract for 21786

GeoGebra Reasoning Tools for Humans and for Automatons

Authors: Zoltan Kovacs, Tomás Recio
Affiliations: The Private University College of Education of the Diocese of Linz, Institute of Initial Teacher Training, Universidad de Cantabria Santander, Spain

We present two recent tools, integrated in the dynamic mathematics program GeoGebra, for automated proving and discovering in elementary geometry. First of all, the GeoGebra Discovery module, with the Relation, Prove, ProveDetails and LocusEquation commands. They are for humans because it is a human who must introduce the objects the human person wants to Relate, the thesis the human wants to Prove or the missing hypotheses the human wants to discover with the LocusEquation command. Moreover, we will describe some tools we have developed within GeoGebra for automatons, such as the Discover(X) and the WebDiscovery. We conclude the paper with reflections on the pros and cons and on the potential impact of these reasoning tools in the educational world.

Abstract for 21788

Group Testing Estimation Using R

Authors: Md Sarker
Affiliations: Radford University, Radford, VA 24142, USA

Group testing (pool testing) has long been used in public health applications for monitoring and detection of infectious diseases. In group testing, pools comprised of individual specimens (blood, swabs, etc.) are tested initially, and then individuals from positive pools are tested subsequently for case identification. This procedure and its variants can offer an enormous amount of cost savings in testing cost. Unfortunately, group testing data are naturally complex, and the statistical methods that model the data are complicated. Consequently, using group testing models in practice is non-trivial, especially for the public health officials who do not have

much background in statistics. Recognizing this as an important issue in surveillance programs, we develop a user-friendly R package called groupTesting to estimate disease probabilities from group testing outcomes. The package provides R functions with a great deal of flexibility and generality for group testing problems, with both single and multiple infections. Computing efficiency of the R programs is greatly enhanced by using compiled FORTRAN subroutines. The work is illustrated using simulation as well as chlamydia and gonorrhea data collected from the Nebraska Public Health Laboratory.

Abstract for 21790

Use of silent video tasks in the mathematics classroom

Authors: Bjarnheiður Kristinsdóttir, Zsolt Lavicza, Freyja Hreinsdóttir
Affiliations: University of Iceland School of Education, Johannes Kepler University Linz, Austria

Starting with an innovative idea from mathematics teachers and teacher educators in a Nordic-Baltic collaboration project, Bea has designed and developed silent video tasks and their instructional sequence within a design-based research project in Iceland.
Silent videos are ½-2 minutes long animated video clips, showing mathematics dynamically without sound or text. In a silent video task, students get to add their voice-over to a silent video, either by creating a screen recording or by recording a sound file. First, the teacher chooses a silent video displaying some previously studied mathematical ic and shows it to the whole class. Next, students get assigned into pairs to view the video as often as they want whilst they prepare and record their voice-over to the video. Students are free to choose what they include in their voice-over, but one can expect some explanations, descriptions, or narratives. All students' responses to the task get listened to and reflected on in a whole group discussion. Teachers can highlight some shared knowledge present in students' responses. Also, ics such as precision in language use and misunderstandings can be addressed and discussed.
Results from the design-based research study indicate that silent video tasks can be used for formative assessment. Teachers can gain insight into students understanding and students get an opportunity to share and become aware of their own knowledge about the mathematical ic shown in the video. Furthermore, it was observed that during implementation of the silent video task, students would participate in the discussion and talk about mathematics with their peers. This was also the case in classrooms where students normally worked silently and individually on problems from their textbooks and were not used to participating in discussions about mathematics.

Abstract for 21794

Safety zone in an entertainment park: envelopes and Maltese Cross related to an offset of an astroid

Authors: Thierry Noah Dana-Picard
Affiliations: Jerusalem College of Technology

There exist different, non totally equivalent, definitions of an envelope of a parameterized family of plane curves. Using software, it is possible to explore the different approaches, either via geometric constructions and automated commands or using analytic methods. In this paper, we explore examples using joint work with a Dynamic Geometry System (DGS) and a Computer Algebra System (CAS). Each package provides its own contributions, and together they contribute to the exploration, to obtain parametric presentations and implicit equations on the one hand, and to have benefit of automatic animations and mouse-driven dynamic work on the other hand. Zooming and increasing precision of approximations are crucial. We study an envelope of a family of circles centered on an astroid, i.e. an offset of this astroid, and explore its physical meaning to determine a safety zone of a concrete device.

Abstract for 21797

An overview of the evolution of DGS in the 21st Century: it is time for algebra

Authors: Eugenio Roanes-Lozano
Affiliations: Universidad Complutense de Madrid

The early dynamic geometry systems (DGS): Cabri Géomètre and The Geometer's Sketchpad were introduced in the early '90s, providing a whole new world of possibilities for geometric exploration. They were manly oriented to education, but can also be used for research.

At the end of the '90s the DGS Cinderella was introduced, including the possibility to work in non-Euclidean geometries. It also performs the internal computations in the set of complex numbers, what is the key for the continuity of some animations.

In 2001 GeoGebra is presented as another classic DGS. But it has a difference with respect to the previous ones: it is free and is willing to be extended through the collaboration of the community of users. It becomes a great success.

A possible evolution of DGS is moving from 2D to 3D. Some present a 3D version (Cabri 3D), others include 3D possibilities from a certain version onwards (GeoGebra) and others are developed directly as a 3D-DGS (Calques 3D).

But the most fruitful development is the approach of DGS to the possibilities of computer algebra systems (CAS). CAS have two main characteristics:

• they can handle unassigned variables, that is, variables in the mathematical sense, not in the computational sense,
• they work by default in exact arithmetic, instead of in floating point arithmetic (what makes numerical computations reliable).

Already back in 2001 the author detailed in a plenary lecture at ICTMT-5 the need for cooperation between DGS and CAS: DGS should incorporate algebraic capabilities. Different approaches have been followed in the 21st century:

• a new DGS that has a small internal CAS and/or can communicate with an external CAS is developed (GDI, Discovery, Geometry Expressions),

• a computational “bridge” between existing DGS and CAS is built (paramGeo, paramGeo3D),
• an existing DGS incorporates algebraic capabilities from a certain version onwards (GeoGebra).

The last step of this evolution is the autonomous work of the algebraic engine of the DGS for automatic theorem proving and discovery (GG-ART).

These evolutions have clearly made DGS much more powerful tools.

Abstract for 21799

Recognizing the Polish Efforts in Breaking Enigma

Authors: Rick Klima, Neil Sigmon
Affiliations: Appalachian State University, Radford University

The work of British and American codebreakers led by Alan Turing at Bletchley Park in breaking the Enigma cipher machine during World War II has been well-documented, and rightfully recognized as one of the most extraordinary achievements of the human intellect. However, without the success of Polish codebreakers led by Marian Rejewski in the 1930s on an earlier version of Enigma, the work by the British and Americans in the 1940s might have taken much longer, prolonging the war at the potential cost of untold additional lives. The mathematics integral to the Polish method for breaking Enigma involved some basic theory of permutations. The purpose of this paper is to present an overview of these ideas and how they served to this effect. To assist in demonstrating this, technology involving Maplets will be used.

Abstract for 21800

Synergistic relationship between computational and mathematical thinking: Implications for teacher education programs

Authors: Jonaki Ghosh
Affiliations: Lady Shri Ram College, Delhi University

The invention of the computer has changed the way we think about mathematics teaching and learning. Papert, in the early 1960s, had referred to the computer as “a mathematics speaking being” and had proposed that children be encouraged to use the computer as “an object to think with”. He talked about “computer cultures”, and delved into how working with computers can influence thinking and reasoning. His pioneering work led to concretizing the term computational thinking (CT), which, in recent times has been identified as an important skill to be developed in children right from the school years. While CT encompasses a broad skill set applicable across contexts and domains, it is also intimately connected with mathematical thinking (MT). The ability to deal with challenging problems, representing ideas in computationally meaningful ways, creating abstractions for the problem at hand, breaking down problems into simpler ones and engaging in multiple paths of inquiry are some of the skills common to both CT and MT. Thus mathematics as a compulsory school subject, becomes the

natural playing ground for integrating CT based activities in the K – 12 curricula. However, developing appropriate tasks, which elicit both CT and MT in students continues to remain a key pedagogical challenge and teacher preparation needs to address this aspect. Mathematics courses in teacher education programs (TEPs) generally cater to school mathematical content and related pedagogy. However, they do not offer any opportunity to specifically address CT.

This talk will focus on the synergistic relationship between computational thinking and mathematical thinking by illustrating examples of CT – MT integrated tasks from school mathematics as well as from outside school mathematics. The suggested tasks, both mathematically and computationally rich, were integrated in a foundational mathematics course in an undergraduate pre service teacher education program. The students who attended the course were from diverse backgrounds in terms of their mathematical ability and interest. Their prior mathematical knowledge included ics taught at the senior secondary level in school, such as, permutations and combinations, probability, trigonometry, coordinate geometry and calculus. The integrated tasks covered a wide range of ics emerging from Fractal explorations, Chaos game, coin weighing problems and cake cutting algorithms. The talk will highlight the potential of such tasks to enable students to engage in the processes of visualization, recursion, iteration, scaling, generalizing, forming decision trees and analyzing algorithms, which are important from both computational as well as mathematical perspectives. Evidence of progression in students' thinking as they engaged with these tasks and their positive feedback led to a convincing argument for integrating such tasks in the mathematics courses of the program. The supporting role of technology in mediating CT and MT was also an important take away from the study.

Abstract for 21809

Browser Based Mathematical Modelling With GXWeb and WolframAlpha

Authors: Philip Todd
Affiliations: Saltire Software

The combination of Geometry Expressions with commercial CAS systems such as Mathematica or Maple make a formidable tool kit for mathematical exploration and modelling. However, these systems are not appropriate for casual use, as they require installation, and are not free. In this paper, we demonstrate the use of the free browser based version of Geometry Expressions: GXWeb, along with the free browser based CAS tool WolframAlpha. Both have taken great strides to enhance usability, while retaining the power of their underlying technologies. We root the discussion in an investigation of the Tschirnhausen cubic, the curve which appears as the catacaustic of parallel oblique beams of light impinging on a parabola. We highlight techniques for moving information between GXWeb and WolframAlpha and for exploiting WolframAlpha's permissive approach to mixing mathematics with natural language.

Abstract for 21810

A Haskell Implementation of the Lyness-Moler''s Numerical Differentiation Algorithm

Authors: Weng Kin Ho, Chu Wei Lim

Affiliations: Nanyang Technological University

This paper describes a computational problem encountered in numerical differentiation. By restricting the problem to a proper subclass of differentiable functions, a numerical solution first proposed by Lyness and Moler is considered and implemented in the functional programming language {\sc Haskell}. The accuracy of the calculation of the numerical derivative using the Lyness-Moler''s method crucially lies in our recursive algorithm for computing contour integrals.

Abstract for 21812

Technology use in secondary mathematics education: A comparative perspective with international large-scale assessment data

Authors: Christian Bokhove
Affiliations: University of Southampton

In the past decades technology has been used in mathematics education in a variety of ways, ranging from LOGO in the early days of the computer, to Computer Algebra Systems and now, among other applications, for dynamic geometry and online applications. Not all applications of technology are successful, though. Recent meta-studies have shown that especially intelligent tutoring systems or simulations such as dynamic mathematical tools were significantly more beneficial than other uses. In many cases, the effectiveness increased if digital tools were used in addition to other instruction methods and not as a substitute. These two developments provide a compelling challenge to classroom resource; on the one hand, there are the existing classroom resources like textbooks, and on the other hand there is technology that can augment and improve these existing instruction methods. Both could be combined in digital mathematics books, but for this to happen, several stars must align, not in the least the general technology uptake for secondary mathematics education in a country.

In this paper, using data from TIMSS 2015 and PISA 2018, I first will give an international comparative overview of technology and resource use in secondary mathematics education. I will show that technology uptake in countries vastly differs for students and teachers. For example, in Australia more than half of students are asked by their teachers to use computers at least monthly for exploring mathematics principles and concepts. In Japan this is only 3%. I will give an overview for more countries and will also include an analogue analysis on internet use. I will explore whether different use is associated with differing achievement levels. The results show vast differences between countries, with some countries integrating numerous technology resources in their secondary mathematics education, and others showing limited technology use. Possible explanations are discussed. I then relate these findings to existing research on the most effective uses of technology in secondary mathematics education, and sketch scenarios for adequate and useful technology uptake. I present several case examples of effective technology use as well. I conclude by integrating the two lines of inquiry. Firstly, we need to focus on the most effective uses of technology for secondary mathematics education. Secondly, for each country, we must explore more fully what stands in the way of successful uptake of these successful methods. In some final thoughts, I sketch a vision where digital mathematics books

could combine and harness many of the affordances of technology use in secondary mathematics education worldwide.

Abstract for 21814

The Role of Technology to Build a Simple Proof: The Case of the Ellipses of Maximum Area Inscribed in a Triangle

Authors: Jean-Jacques Dahan
Affiliations: IRES of Toulouse

We know that there is a unique ellipse inscribed in a triangle and passing through the midpoints of its sides. This ellipse is known as the Steiner ellipse. Among the properties of this special ellipse, one states that it is the ellipse of maximum area inscribed in a triangle. The first complete proof of this property was given in 2008 by Minda and Phelps. Their proof uses lots of properties of complex numbers and especially the complex forms of some transformations. When I read this proof for the first time, I was unpleasantly surprised by its complexicity. From this moment, I worked on an approach of this property using dynamic geometry and Computer Algebra System. My aim was initially to find investigations that could lead to this property. I was successful but what was astonishing is that I could build a proof of this property following the stages of the previous investigations. This paper will discribe first, how the investigations conducted with technology led to the expected conjecture and secondly how a simpler proof could be built in translating with CAS the stages of the investigations ([1']). This process is really unusual because, it is known that there is a gap between the conjecture and the proof in an experimental process of discovery mediated by technology (or not). The story of this research will give an example of bridging the stage of conjecture and the stage of proof ([2']). We will also have the opportunity to show how the possibilities of a software can influence our constructions and the way to conduct our proofs: here we will conduct a backward reasoning which is the core of the simplification provided by my proof. As usual in any research work, we will give some extra results met during our investigations (construction of all ellipses inscribed in a triangle, simple constructions of isoptics…).

Abstract for 21820

The geometry of impossible figures

Authors: Alasdair McAndrew, Jacob Baker
Affiliations: Victoria University, Melbourne Australia, Mathematics Department Alexandra Park School Bidwell Gardens, London N11 2AZ UNITED KINGDOM

"Impossible figures" are those that can be drawn with perspective in two dimensions, but cannot exist in the physical world. Well known examples are the Penrose triangle, the Penrose staircase, and the ``impossible trident"". The Dutch artist Maurits Escher (1898--1972) took great delight in such figures and incorporated them into many of his works. Less well known is the Swedish artist and graphics designer Oscar Reutersv\"ard (1916--2002), who drew and developed hundreds of such figures, and who has been honoured by some Swedish postage stamps showing

his designs. Some art installations now include such figures, but which only seem impossible from one particular perspective. In this article, we explore the geometry of such figures, and discuss how such figures can be drawn using standard programming tools. The mathematics required is elementary, but not
without subtlety, and with the delight of producing some lovely diagrams.

Abstract for 21823

NetPad: Using Technology to Promote the Reform of Mathematics Education

Authors: Hao Guan, Gang Yao
Affiliations: cas, jzjy

With the development of computer technology, the dynamic geometric system is constantly innovating. From the perspective of application scenarios, we divide it into three main development stages: application stage, Internet stage and mobile Internet stage. In the mobile Internet stage, the positioning and coordination of different devices and the organization and sharing of digital resources are major challenges. NetPad is a dynamic mathematical digital resource platform conceived and developed in the mobile Internet stage, and includes a two-dimensional and a three-dimensional dynamic geometric system. Examples will be given to illustrate the functions, interaction methods and main application scenarios of its dynamic geometric system, resources and platform.

Abstract for 21824

Computational thinking as habits of mind for mathematical modelling

Authors: Keng Cheng Ang
Affiliations: Nanyang Technological University, 1 Nanyang Walk, Singapore 637616

The growing interest in computational thinking and its use in problem solving had led teachers and educators, as well as other researchers, to ponder over what it means and how best to introduce such a notion to students in schools. Many ideas on “teaching computational thinking” have also been suggested, and in many countries, courses on coding have been made very popular as more people begin to believe that the ability to write code is an important skill in this increasingly digital world. In this paper, we focus on the habits of mind that are related to computational thinking and that can be developed from learning to code. Some of these habits include looking at trends in data and analyzing them, examining a process and simulating it, and systematically constructing a solution to a problem. More specifically, we shall discuss how these habits of mind can enhance and support one’s skills and competencies in the context of mathematical modelling, using three examples. Individually, each example illustrates some aspects of computational thinking applied to the modelling tasks. Collectively, through these examples, we attempt to demonstrate that the related habits of mind of computational thinking, developed through coding exercises, could strengthen one’s ability and expand one’s capability of tackling modelling tasks in a significant, albeit sometimes subtle way. The paper concludes

with a brief discussion on possible directions of work that could further exploit computational thinking in mathematical modelling.

Abstract for 21825

How important is the user-interface to dynamic software?

Authors: Douglas Butler
Affiliations: iCT Training Centre (Oundle, UK), Autograph-Maths

Autograph is now free to download, thanks to La Salle Education and "Complete Maths", so joins Desmos and Geogebra on the give-away table. This is a useful opportunity to compare the three very different user-interfaces, and to evaluate their effectiveness.

Autograph is still a desk application, and relies on a well tried system of object selection then right-click. The right-click menu lists the options that are relevant to the object selection. Geogebra uses the opposite selection process: choose the operation then the objects (as did Cabri). Sometimes this is to be preferred, but not always. Geogebra gets a lot of its power from the use of command line entries, which some teachers find quite demanding. Desmos was born in the cloud, so has the best web performance and online participation. However Desmos has the smallest feature list as it is not really dynamic object-based software.

By the time of this presentation a web version of Autograph will be nearing completion.

This presentation will take a number of ics from the high school curriculum and see how the three platforms compare.

Douglas Butler
Twitter: @douglasbutler1
Home page: www.tsm-resources.com

Abstract for 21826

Maple in the Classroom: Strategies, Experiences and Lessons Learned

Authors: Douglas Meade, Paulina Chin
Affiliations: Maplesoft, University of South Carolina

Interactive applications that demonstrate mathematical concepts are valuable tools for students, whether they are used in a classroom setting or for self-study purposes. Instructors can easily find a large number of ready-made applications for a variety of subjects. However, sometimes you need to build your customized interactive resources.

Prof. Meade will show various applications that he has developed over the past 30 years for use in calculus, linear algebra, and differential equations classes. These include Maplets for Calculus, a collection of 201 Maple applets designed for use by students and instructors in calculus and

precalculus. He will talk about his philosophy and current best-practices for building these applications, using them in the classroom and adapting them for different audiences.

All the applications described in this talk were created in the mathematics software package Maple. Dr. Chin will describe the current tools available in Maple that allow instructors to quickly get started in creating their own interactive educational resources. These tools make it easy to incorporate Maple's extensive library of mathematical functions with ready-made graphical components.

The presentation is accessible and meaningful to all Maple users, novice and experienced, and even to non-Maple users as the pedagogical philosophies and best-practices are not software specific.

Abstract for 21827

Understanding Geometric Pattern and its Geometry (part 3) – Using Technology to Imitate Medieval Craftsmen Designing Techniques

Authors: Miroslaw Majewski
Affiliations: New York Institute of Technology, Abu Dhabi Campus

The medieval artists produced incredibly complex geometric art using very basic tools – a ruler, simple compasses and a number of templates drawn on a parchment or on a paper. This was all what they had and all what they needed. They did not have computers, AutoCAD or printers. Nowadays with all the modern tools we still have problems with reconstructing correctly the old geometric art and our easy-to-use tools do not help much.
In this paper we will explore the possible ways of creating geometric patterns using a simple geometry software and following the old XV century methods.

Abstract for 21829

Exploring Locus Surfaces Involving Pseudo Antipodal Points

Authors: Wei-Chi Yang
Affiliations: Radford University

The discussions in this paper were inspired by a college entrance practice exam from China. It started with investigating the locus curve that involves a point on the given curve and a pseudo antipodal point with respect to a fixed point. With the help of several technological tools, the problem leads author to explore 2D locus for some closed curves.
Later, we investigate how a locus curve can be extended to finding the 3D locus surfaces on surfaces like ellipsoid, cardioidal surface and etc. Secondly, we use the definition of a developable surface (including tangent developable surface) to construct the corresponding locus surface. In robotics it is well known that antipodal grasps can be achieved on curved objects. In addition, there are many applications already in engineering and architecture about the

developable surfaces. We hope the discussions regarding the locus surfaces can inspire further interesting research in these areas.

Abstract for 21830

Designing Mobile Apps to Address Mathematical Gaps in the Context of a Developing Country

Authors: Ma. Louise Antonette De Las Penas, Debbie Marie Verzosa, Jumela Sarmiento, Mark Anthony Tolentino, Mark Loyola
Affiliations: Ateneo de Manila University, University of Southern Mindanao

Developing countries typically do not perform well in international benchmarks of mathematics achievement. This may be partially explained by students' immersion in classrooms characterized by superficial strategies or rote-learning methods. This paper reports on the design of mobile applications (apps) developed by the authors as part of an ongoing project funded by a national government agency and intended to promote structural thinking and statistical reasoning. It describes the general features of the apps, as well as the pedagogical principles upon which the apps' designs were anchored on. These principles are grounded on research and established practices on number sense and statistical learning. Collaborations with the Philippine Department of Education for widespread implementation and sustainability are also discussed.

Abstract for 21832

What's in a name? Using a scientific calculator for mathematical exploration in schools

Authors: Barry Kissane
Affiliations: Murdoch University

This paper identifies a problem that calculators are often interpreted as devices whose sole purpose is to undertake numerical calculations, with the result that their educational significance in secondary schools is not understood well, in contrast to other forms of ICT, for which the software capabilities are recognised as the key features. It is suggested that the potential for educational use of calculators in many Asian contexts is undermined by this limited understanding of their capabilities. An important use of calculators in secondary schools beyond mere calculation involves mathematical exploration, which is described in the paper. Several examples of ways in which features of scientific calculators might be productively used for mathematical exploration are outlined, to indicate the range of contexts of relevance. Ways in which such features might be used in schools are described.

Abstract for 21834

Maths in the Time of Corona: Experiences in Remote Education

Authors: Dóra Szegõ, Ildikó Perjési-Hámori, György Maróti

Affiliations: University of Pécs, Faculty of Engineering and Information Technology, Department of Engineering Mathematics

This presentation reflects on the spring semester of the 2019/2020 academic year.
The COVID-19 global health crisis has brought traditional university education to a halt. At the University of Pécs we had eleven days to make the transition to remote education. In trying to overcome the obstacles some new methods were developed to teach Mathematics in the Department of Engineering Mathematics: Microsoft Teams, Zoom, Möbius TA, Neptun, Unipoll or even YouTube were utilized. The presentation covers the experiences of Mathematics for Information Technology 2 in detail: how the classes were held, the kind of homework given, the structure used for grading, and most importantly how Möbius TA was used in the final exams.
Computer aided test and assessment is widely used to support the teaching and learning of mathematics [1, 2]. During the design of the questions Bloom's taxonomy [3] was taken into account (the levels are knowledge, comprehension, application, analysis, synthesis, evaluation). All questions' title refer to the taxonomy level.
Phases of development:
1. Planning: what, to whom, at which level. Detailed development of curriculum
2. Data acquisition: selection of the types of exercises, splitting the exercises into parts, weighting, finding the correct wording, correct answer
3. Programming, close teamwork between curriculum developer and IT expert.
4. One-by-one testing
5. Construction of different assessments for different purposes (practicing, self-regulation, exam)
6. Collecting feedback from students and teachers, revision of questions.
In our presentation, the results of students with and without on-line test and assessment will be discussed. Our goals were
• for students: assessing their own knowledge of a particular ic,
• for teachers: getting feedback from the level of knowledge of learning material.
References:
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Abstract for 21835

Transfigurations of Polyhedra

Authors: Jen-chung Chuan
Affiliations: Department of Mathematics, National Tsing Hua University, Hsinchu, Taiwan 300

In this study, we are to present animations in the form of short video clips showing how polyhedron A can be changed in appearance to polyhedron B, where A, B are particular types of

Catalan solid, Archimedean solid or Platonic solids. Since each such transfiguration is in one to one correspondence with the nets of a particular polyhedron, and since the algorithm for generating all such nets is yet to be developed, the author would welcome your feedback on improvements in making a more efficient video production.

Abstract for 21836

Using technology in mathematics teaching and learning: Sure, but why and how?

Authors: Michael Bosse, Anthony Dove
Affiliations: Appalachian State University, Radford University

There is little doubt regarding the value of technology in mathematics teaching and learning. Most research and practices even seem to accept this unquestioningly. But, is this enough? We must begin to consider more deeply why and how we use technology in the mathematics classroom. In this session, we will discuss Instrumental Genesis, Representational Determinism, Uses of Technology, the IGS framework, and Implications of classroom implementation of mathematics learning technology.

Instrumental Genesis. Instrumental Genesis (IG) recognizes that a tool (with its constraints and possibilities) and a subject (with his/her knowledge and work ethic) interact as an instrument through which to do a task (Artigue, 2002; Lagrange, Artigue, Laborde, & Trouche, 2003; Trouche, 2005). Trouche (2018) recognizes instrumentation as how the tool affects the subject, instrumentalization as how the subject affects the tool, and mediation as the interaction of the two. Thus, discussing either technology or the teacher/students independent of the other is nonsensical.

Representational Determinism. Traditional mathematical representations include: numeric (or tabular), symbolic (or algebraic), graphical (or pictorial), and verbal (written or oral). More recently, the literature has recognized dynamic math environments (DMEs) and dynamic technology environments (DMEs) as an additional type of mathematical representation (Brown, Bossé, & Chandler, 2016). All representations have inherent strengths and weaknesses. Any representation or manipulative provides only a partial embodiment of underlying mathematical ideas, while ignoring or even slightly distorting others (Goldin & Shteingold, 2001). In a given mathematical domain or task, the representation itself not only impacts the information that can be directly perceived and used, but also limits the range of possible cognitive actions by allowing some, prohibiting others, and impacting behavior. (Bossé, Lynch-Davis, Adu-Gyamfi, Chandler, 2016)

The term, representational determinism (Zhang, 1997), defines how the form of a representation affects: what mathematical information can be perceived or distorted; what mathematical processes can be activated; and what mathematical structures can be explored and discovered. Thus, the selection and use of a representation resides not only in the mathematics being addressed but also in the determinism of the representation. In order for representations to be used correctly, users must understand each representation's associated, contextualized determinism (Bossé, Lynch-Davis, Adu-Gyamfi, Chandler, 2016). Unfortunately, the seeming simplicity with which some believe that technology can be implemented in the classroom can lull some to use technology in means which may lead to lessened pedagogical and epistemological benefits.

Uses of Technology. There are three primary uses of technology in the classroom: Presentation; Pedagogical (teaching) – to teach a concept, to enhance/extend a concept, to assess student understanding, and to remediate a concept; Epistemological (learning). These dimensions are very different applications of technology, and must be thoroughly understood by educators intending to employ technology in the mathematics classroom. Any plans to use technology should include more than just a list of activities for students to perform; plans and activities should be founded upon why it is being used in such a manner.

Interactive Geometry Software Framework. The Interactive Geometry Software (IGS) Framework considers whether the use of technology acts as an amplifier (students could achieve the same goals without the technology) or as a reorganizer (the mathematical goal of the task would be difficult to achieve without IGS) (Hollebrands & Dove, 2011; Sherman & Cayton, 2015). Understanding this framework helps the educator to understand the nature of the activities and technology use, how students interact with the technology, and what affordances the technology provides the learner. (Note how this circles back to IG.)

Implications. The implications of these dimensions are myriad and are important to consider when employing technology. For instance: not all uses of technology improve learning; technology use in teaching and learning is not a panacea; and technology use can both improve strengths and accentuate weaknesses among student learners (Jobrack, Bossé, Chandler, & Adu-Gyamfi, 2018).

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Abstract for 21847

How technology affects problem-posing activities?

Authors: Zoltán Kovács
Affiliations: Eszterházy Károly University, University of Debrecen

Problem-posing is a priority area for the development of mathematical competence in addition to problem-solving. In the problem-posing activity, whether we start from a known problem or a real-life situation, we must first discover the case, come to conjecture, or even test one of our inferences on additional examples. So, the flexibility of computer-based technologies (including programming) for facilitating exploration and experimentation seems relevant to problem posing. This situation naturally raises the question: How can technology be used in problem-posing activities? (Singer, Ellerton, & Cai, 2015).
In the first part of my lecture, I will give a brief overview of how technology appears in Hungarian mathematics textbooks (grades 5-8). I then examine examples of the problem-posing activities of teacher candidates, primarily in terms of didactical coherence (Abramovich & Cho, 2015). In conclusion, I argue that the application of technology can open up new curriculum perspectives in the teaching of mathematics in a didactically consistent way.
Although geometric tasks appear to be particularly well suited to the dynamic visualization power of computer-based tools to aid in problem posing, I also investigate technological tools in other mathematical contexts.

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Abstract for 21848

Delivering a computer-based maths curriculum

Authors: Alec Titterton

Affiliations: Computer-based Maths, Wolfram Research

Abstract for 21854

ExDiD: Trendy Teaching Method to WOW Your Students

Authors: haslinda ibrahim, Masnita Misiran @ Bakun Misiran @ Bakun, Norhayati Yusof yusof

Affiliations: school of quantitative Sciences, universiti Utara Malaysia, kedah 06010 Malaysia, school of quantitative Sciences, universiti Utara Malaysia, kedah 06010 Malaysia

ExDiD(Explore, discover, develop) method is being adopted for creating ambiance learning environment to meet future demands and challenges. This innovative teaching method is based on three main criteria, namely “Explore, Discover, and Develop ” to create a curious mind in learning mathematics by engaging students in the learning of the subject. Students were coached to solve problems based on the ExDiD method. The first phase, which is called “Explore” is the process where the students are free to explore the material/problem given to them. This phase is the basic principle in understanding ideas or concepts related to the given scenario. In this category the students are trained to do brainstorming for any given problems they have to solve. Then, the “Discover” phase is where the students execute some possible arrangements or enumerations for several cases that are appropriate to the given problems. This task is crucial in the investigation of the relationship towards providing solutions to the problem. Finally, the “Develop” phase is where the students construct the design for the solution. In this phase, students eventually construct the formulae, procedures, algorithms, or plans for the concluding solutions. To facilitate deep learning, the activities are conducted in small groups of four to five students. Collaboratively, each group shall explore the nature of the problem, then discover the patterns of solving problems from various aspects and finally, they shall develop an optimal strategy to reach the solution. This novel teaching method ExDiD forms a strategic chain of core processes in building critical thinking, which is fundamental in problem solving and decision making. This article will showcase the voyage of ExDiD in teaching and learning.

Abstract for 21855

Using Computer Algebra and Computer Numeric Systems to support a deeper understanding of Applied Mathematics

Authors: Alexander Edthofer, Milena Sipovac, Stefanie Winkler, Andreas Körner
Affiliations: TU Wien

At the TU Wien different methods and concepts are applied to teach students the power and possibilities mathematics provide for engineering science. The last semester has shown that it is important to use computer systems to enable individual feedback and learning. Different tools are applied for different lectures and exercises. On the one hand, there is the basic math courses for engineers. On the other hand, there are various courses given in the field of mathematical modelling and simulation. This field may already suggest the usage of computer systems. But in both subjects the basic theory is an important aspect of studying. The only remained question is how to enable the self-education for the exercising part of the courses.

Abstract for 30001

Three Aspects of Maple for Education

Authors: William C. Bauldry
Affiliations: Appalachian State University, North Carolina

We discuss three aspects of utilizing the computer algebra system Maple to enhance learning. First, we consider Maple as platform to develop both static and dynamic images and displays for classes and for students for their studies. Second, we consider Maple as a student exploration tool under the Action-Consequence-Reflection Principle where a student acts on a mathematical object, observes the consequences of their action, and reflects on the mathematics of the situation. Third, we look at Maple as a tool to support mathematical exposition via linking to documents, posting worksheets in the MapleCloud, and by creating packages of routines and programs to support a document.