



ALM26 Conference Proceedings

7th – 10th July 2019
Lund, Sweden

Proceedings of the 26th International Conference
of Adults Learning Maths – A Research Forum (ALM)

Hosted by Faculty of Engineering, Lund University
Center for Mathematical Sciences

Edited by
Charlotte Arkenback Sundström and Linda Jarlskog

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Pictures: Photography by Linda Jarlskog



Top: David Kaye during the first evening of the conference.

Top: The social activity was a guided visit to Lund Cathedral with a focus on mathematics.

Middle: A lot of activity and discussions during the parallel sessions.

Middle: Musical talents from different countries were represented during the conference dinner.

Bottom: The conference dinner was held at Hypoteket in Lund.

Bottom: A view from the rooftop during the conference dinner at Hypoteket.

Maths in a Digital Age

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of Adults Learning Maths – A Research Forum (ALM)

Hosted by Faculty of Engineering, Lund University
Center for Mathematical Sciences

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Edited by

Charlotte Arkenback Sundström and Linda Jarlskog

Local Organisers

Linda Jarlskog, Charlotte Arkenback,
Hans Melén and Rose-Marie Wikström

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Conference host

Faculty of Engineering, Lund University
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National Center for Mathematics Education (NCM), Gothenburg, Sweden

Adult Education in Cooperation (ViS), Sweden

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About ALM

Adults Learning Mathematics – A Research Forum (ALM) was formally established in July, 1994 as an international research forum with the following aim:

To promote the learning of mathematics by adults through an international forum that brings together those engaged and interested in research and development in the field of mathematics learning and teaching.

Charitable Status

ALM is a Registered Charity (1079462) and a Company Limited by Guarantee (Company Number: 3901346). The company address is: 26 Tennyson Road, London NW6 7SA, UK.

Aims of ALM

ALM's aims are to promote the advancement of education by supporting the establishment and development of an international research forum for adult mathematics and numeracy by:

Encouraging research into adults learning mathematics at all levels and disseminating the results of this research for the public benefit.

Promoting and sharing knowledge, awareness and understanding of adults learning mathematics at all levels, to encourage the development of the teaching of mathematics to adults at all levels for the public benefit.

ALM's vision is to be a catalyst for the development and dissemination of theory, research and best practices in the learning of mathematics by adults, and to provide an international identity for the profession through an international conference that helps to promote and share knowledge of adults' mathematics teaching and learning for the public benefit.

ALM Activities

ALM members work in a variety of educational settings, as practitioners and researchers, to improve the teaching and learning of mathematics at all levels. ALM holds an international conference each year at which members and delegates share their work and meet each other in an academic but informal environment. The conference enables an international network which reflects on practice and research, fosters links between teachers, and encourages good practice in curriculum design and delivery using teaching and learning strategies from all over the world. ALM does not foster one particular theoretical framework, but encourages discussion on research methods and findings from multiple frameworks. ALM produces and disseminates Conference Proceedings and a multi-series online Adults Learning Mathematics – International Journal (ALM- IJ).

ALM holds an international conference each year at which members and delegates share their work, meet each other, and network. ALM produces and disseminates Conference Proceedings and a multi-series on-line Adults Learning Mathematics – International Journal (ALM- IJ).

ALM website

On the ALM website <http://www.alm-online.net>, you will also find pages of interest for teachers, experienced researchers, new researchers and graduate students, and policy makers.

Teachers: The work of members includes many ideas for the development and advancement of practice, which is documented in the Proceedings of ALM conferences and in other ALM publications.

Experienced Researchers: The organization brings together international academics, who promote the sharing of ideas, publications, and dissemination of knowledge via the conference and academic refereed journal.

New Researchers and Ph.D. Students: ALM annual conferences and other events allow a friendly and interactive environment of exchange between practitioners and researchers to examine ideas, develop work, and advance the field of mathematics teaching and learning.

Policymakers: The work of the individuals in the organization helps to shape policies in various countries around the world.

ALM Members

ALM Members live and work all over the world. See the ALM members' page at www.almonline.net for more information on regional activities and representatives, and for information on contacting your regional representative. How to become a member: Anyone who is interested in joining ALM should contact the membership secretary. Contact details are on the ALM website: www.alm-online.net.

Membership fees for 2019

	Sterling	Euro	US Dollar
Individual	20	24	32
Institution	40	48	64
Student/unwaged	4	6	7
Low waged	Contribute between full and unwaged		

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ALM is managed by a Board of Trustees elected by the members at the Annual General Meeting (AGM), which is held at the annual international conference.

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Conference host and conference co-hosts

Conference host

Lund University was founded in 1666 and is ranked among the world's top 100 universities. The Faculty of Engineering is one of the eight at the University. The Center of Mathematics Science is part of the Faculty of Engineering.

Center of Mathematics Science, Lund.

Conference co – hosts

The National Center for Mathematics Education – NCM - Sweden

NCM's task is to support the development of mathematics education in preschool, in the compulsory and voluntary school system. NCM was established through a government decision in January 1999. NCM is one of several resource centers for various school subjects established over the last 20 years.

The center is located at the University of Gothenburg and is led by a manager who, together with the center's staff, transfers overall decisions.

Among NCM's staff are people who have a background, or who work as teachers, teacher educators, researchers and mathematicians. They are responsible for and participate in various activities and projects such as

- o publishing of the magazines Nämnaren and NOMAD
- o publishing literature for teacher education and teacher training
- o participation in and arrangement of seminars, courses and conferences
- o operation and development of multiple websites.

Adult Education in Cooperation – ViS - Sweden

ViS is a national organization for the adult education that is politically unbound and on a nonprofit basis. Municipal and private education coordinators as well as commissioners of adult education across the country form the basis of ViS members.

ViS takes care of the interests of adult education towards the parliament, government, municipalities, central authorities and other organizations. The main issues are better infrastructure, increased accessibility, higher quality and educational development. By driving the development in these areas, ViS create good conditions for course participants and students to achieve their goals.

Open access publication

ALM 26 Proceedings Editors: Charlotte Arkenback-Sundström and Linda Jarlskog.

ALM 26 Local Organisers: Linda Jarlskog and Rose-Marie Wikström.

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Photos front and back cover:

The Cathedral of Lund. Photo: Linda Jarlskog

Thread Model of a Transcendental Ruled Surface by Klas Anshelm. Photo: Linda Jarlskog

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Others

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Anders Jarlskog, founder of the Fulltofta castle banquet hall, and Paul Antognoli, Restaurant Manager and Sommelier of the Hypoteket, for a memorable welcome session and a magnificent conference dinner.

ALM 26 Chair's Introduction

by David Kaye

The Answer is 42.

At the 26th ALM Conference held in Lund, Sweden my final action as Chair of Trustees for the past four years was to give an introduction to the Conference as part of the welcome on the first morning.

The title of the conference was 'Math in a Digital Age'. This presented me with some unusual difficulties. Whilst I recognise this is of great importance to teaching adults mathematics in general, and essential to mark ALM's commitment to technological development, personally I remain an interested observer of these developments.

Setting out to introduce such a conference therefore required me to draw on all my 30 years experience of teaching adults numeracy, research into adult mathematics education and some awareness of the history of mathematics.

I began by considering the visual connection between 'digital' and 'digit'. This led to a representation of the transformation of 'digit' to 'number'. I was on safer ground! (I must here express my thanks to my colleague Daian Marsh and her son, Kyle, for the impressive animation they built.)

I was now able to draw on my conceptual knowledge of number and the history of numerals. I have used an array of different numerals representing the same 'number' in many teaching and training contexts. Usually this is to indicate that we need to be careful as the word 'number' can have various meanings: referring to what words we use, how we represent it with symbols or conceptually an amount or quantity.

The array I presented showed the same 'amount' in various symbols and patterns including Mesopotamian cuneiform, Roman numerals, various dot grids and in digital form. We discussed some of the representations and how they related to teaching numeracy. We used some of the newly introduced conference technology for number words in various languages to be posted. The more obscure numerals from distant times were explained.

And was the number interesting in itself? Possibly. The number was 'forty two'. This was taken from the Hitch Hikers Guide to the Galaxy by Douglas Adams¹. Perhaps about half of the participants present were aware of the significance of this number in this spoof science fiction story. (If you are amongst those who are not aware I suggest you do a little research – you will be well-rewarded.)

So I introduced our 21st century conference with a reminder that we are continuing a 5000 year tradition of helping our communities to work with and enjoy numbers.

¹The Hitch Hikers Guide to the Galaxy by Douglas Adams was originally written as a script for radio and broadcast by the BBC in 1978. It has subsequently been published and commented on in many formats.

There is a post-script to this introduction which continues to point to the ubiquity of XXXXII. After the sessions on the first day of the conference many of the participants attended a tour of Lund Cathedral which included an introduction to the astronomical clock and examples of questions prepared for children bringing mathematics into exploring the Cathedral. One task was to count or calculate how many wooden statues were on an alter screen. There were many ways to group these statues to speed up counting. Whichever way you worked it out – the answer was 42!

Thank you to all who participated in ALM26 and contribute to Adults Learning Mathematics continuing to take its message across the world.

Preface: About ALM 26

The 26th international conference of Adults Learning Mathematics – A Research Forum (ALM 26) was held in Lund, Sweden.

The conference was organized by ALM together with NCM (National Center of Mathematics) and ViS (Adult Education in Cooperation, Sweden), and was funded by Euro Finans and the community of Lund. The conference was spread over three days. The conference was attended by approximately 70 researchers, practitioners and policymakers, from 15 countries (Australia, Canada, the Czech Republic, Denmark, Greece, Germany, Ireland, Japan, the Netherlands, Norway, South Korea, Sweden, Switzerland, the United Kingdom and the United States of America).

The main theme of the conference was ‘Maths in a Digital Age.’ This was not only the theme connecting the contributions but also the emphasis put on communication within the Conference. Participants were guided through the use of a conference padlet and flip grid at the opening session by Charlotte Arkenback-Sundström. The conference encouraged a range of creative and dedicated speakers to present a series of parallel sessions throughout the conference. These proceedings present those sessions in short papers, lightly edited but not peer-reviewed. There were also three inspirational plenary speakers: Professor Andreas Fejes (professor and chair of adult education research at Linköping University, Sweden), Ola Helenius (researcher and designer of mathematics teaching models and competence at NCM, Gothenburg, Sweden) and Associate professor Kees Hoogland (University of Applied Sciences, Utrecht, The Netherlands).

On Monday Ola Helenius gave us a broad introduction to his views of mathematics, particularly seeing mathematics as a cultural product. He connected this to his own interest in the design of wind surfing boards. From this we were directed to consider how the design of curves is represented by a series of co-ordinates which leads to digital resource design. Thus the talk completed the arc of thought from the philosophy of mathematics to mathematics in the digital age.

On Tuesday Andreas Fejes gave an overview of the structure of adult education in Sweden. We were both educated about the current provision for adults in Sweden and presented with a critique of some significant recent changes to that provision. There was considerable evidence that recent changes had seen the growth of market forces in the system which had been to the detriment of the education provided. In conclusion we were warned that in this context 'free choice creates segregation'.

On Wednesday Kees Hoogland gave the final plenary. Its starting point was identifying the relevance of taking a social practice approach to adult numeracy research. We were reminded that as recently as the 1950s 'calculators' were employees who did calculations. The presentation moved on to identify aspects of the social practice approach particularly viewing adult mathematics education research as integrated and holistic with a timeline looking forward to 2050. The final part of the talk introduced us to some draft investigative tools being used to develop the Common European Numeracy Framework for an Erasmus+ programme.

During the opening ceremony on Sunday evening at Hypoteket in Lund, Tomas Persson from Lund's mathematical community was invited to speak about the history of mathematics in Lund. The social activity on the Monday evening was a guided visit to Lund Cathedral with a focus on mathematics, which we thank the Cathedral's own educators for.

Like the opening ceremony, the conference dinner was held at Hypoteket on the Tuesday evening. The Student singers from Lund were invited as entertainment during the meal. After the meal there was an opportunity for the main organisers Charlotte Arkenback-Sundström, Linda Jarlskog and Rose-Marie Wikström to be thanked for the success of the Conference and appreciation for the work of David Kaye as the outgoing Chair of ALM was also made. The evening concluded with a demonstration of the musical talents from all the countries represented at the Conference.

Note: Papers for these Proceedings are based on the long abstracts prepared by presenters for the Conference. They have been up-dated and edited and in some cases longer versions have been submitted. It is a recent decision of the Trustees of ALM to use revised versions of the long abstracts, which are lightly edited, but not peer reviewed, as papers for the proceedings. Conference presenters are still invited to submit longer articles for peer review based on conference presentations to the ALM International Journal editor-ij@alm-online.net.

Theme of the conference

The overall theme of ALM 26 was 'Maths in a Digital Age'.

Learning has been influenced by technology at least since the prehistoric time when humans started to create cave paintings to communicate information. What separates digital systems from the previous technologies of writing, painting, photo, film and audio recording is that they are interactive. Learning takes place in a technology-enabled world of internet networks, websites and mobile devices in and out of the classroom. A new era of learning and communicating mathematics is emerging giving rise to questions within the field of adult learning mathematics.

- o How do digital technologies influence mathematical learning?
- o Do our current mathematical teaching and learning practices benefit from this technology?
- o How do digital technologies affect ways of understanding mathematics?
- o What significance does new technology have in older learners' learning process?

The conference particularly welcomed contributions on technology-enhanced learning within adult mathematics education, for example programming, mobile-learning, e-learning, computer-collaborative learning, e-assessment for learning, teaching with digital technologies or math in a digitalized workplace.

Presentations

Using students' rationales for learning to individualize instruction

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This study reports on a case study of a student's rationales for studying mathematics. We operationalize Stieg Mellin-Olsen's educational concept of rationales for learning and apply the concept on data consisting of three semi-structured interviews with a student in the Swedish prison education program. Our analysis shows that the student's rationales vary considerably in strength over time, but also changes in character as a reaction to his educational contexts. We conclude that Mellin-Olsen's construct of rationales is useful for understanding students' changing motivation in relation to the teaching and to the practice of mathematics the teaching entails. Teachers may use the concepts from our analysis as cognitive tools, to think, talk and relate to students' rationales for learning. By identifying and acting on students' different rationales, opportunities arise for an individualized instructional design of mathematics courses.

That motivation can be of different types is well documented in research (Ryan & Deci, 2000). A common denominator for motivational theories is that they seek to answer how to get students to accept the basic premise of learning, schooling, and mastery of the material that the instructors prescribe are important (Graham & Weiner, 1996). Reflecting on the question: "Shall students adapt to teaching or shall teaching adapt to students?" we believe the latter is a more promising approach for organizing individualized instruction for adult mathematics learners. But, adapting teaching to students requires certain information of the students' driving forces for participating in the learning of mathematics.

In this presentation we report on a case study of an adult student's rationales for learning mathematics in prison. We elaborate on the question: How you can characterize

students' motivation for studying mathematics in relation to their social and educational contexts based on a socio-political theoretical perspective. We use Mellin-Olsen's (1981; 1987) educational concepts, S-rationale and I-rationale for learning, as a conceptual framework. Mellin-Olsen defines the sociological S-rationale as follows:

This rationale for school learning I have called the S-rationale to indicate its social importance. It is the rationale for learning evoked in the pupil by a synthesis of his self-concept, his cognition of school and schooling, and his concept of what is significant knowledge and a valuable future, as developed in his social setting. (Mellin-Olsen, 1981, p. 357)

Different conceptions of what constitutes "good knowledge" may cause the student to have conflicting rationales for learning. While finding himself to be bored beyond belief by mathematics, he may very well be aware of the fact that mathematics is inevitable for moving on to the next level of the educational system. This reproduction of labor force, with mathematics as a gatekeeper, is represented by the I-rationale for learning:

It is the rationale, which is related to school's influence on the future of the pupil, by the formal qualifications it can contribute. This role as an instrument for the pupil will provide the pupil with an instrumental rationale (I-rationale). In its purest form the I-rationale will tell the pupil that he has to learn, because it will pay out in terms of marks, exams, certificates and so forth. (Mellin-Olsen, 1987, p. 157)

Using these concepts, we show how a student's rationales vary considerably in strength over time, but also changes in character as a reaction to his educational contexts. We also give examples of how the teacher successfully adapted the teaching situation to the student's social setting.

Method

To investigate if one can use the educational concepts S- and I-rationales to characterize students' motivation for studying mathematics, we conducted and analysed semi-structured interviews with imprisoned adults, studying mathematics in the prison education program. In this presentation we focus on one case, the student Bill. Drawing on Powell, Francisco and Maher's (2003) principles for analysing video data, the interviews were recorded and all parts concerning Bill's relation to mathematics were transcribed. We coded all critical events referring to Bill's rationales for studying mathematics and categorized them as belonging to the S-rationale or the I-rationale for learning, in line with the operationalization described below. Thereafter we constructed a storyline, which formed the basis for a chronological narrative of Bill's history of

rationales for studying mathematics. While the timeline was constructed in relation to Bill's chronological experiences from schooling, critical events relating to one time segment in Bill's life came from different time points in the interviews.

Findings

We conclude that the theoretical construct of instrumental and sociological rationales for learning is useful for understanding students' changing motivation in relation to the teaching and to the practice of mathematics the teaching entails. Since the constructs are easy to apply, teachers can use them as cognitive tools, to think, talk and relate to students' rationales for learning. By identifying and acting on students' different rationales, opportunities arise for an individualized instructional design of mathematics courses.

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Adults Learning About Probability and Risk in Health-Related Contexts: Creating an Online Learning Instrument

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After a brief introduction to the conceptualization of health numeracy and thinking behind our online health numeracy teaching and learning instrument, we outline how we created lessons about probability, chance and risk. Our major challenge came from the fact that although adults need a good understanding of major probabilistic ideas (many of which are not intuitive), that understanding should not come from formal definitions, theorems and algorithms, as in mathematics courses. Given the diversity of the background preparation, knowledge and demands of our intended users, we built a trajectory from the very basic principles (such as understanding what 25% actually represents), to dealing with data uncertainty, to explaining conditional probabilities and the law of total probability (as they are needed in reasoning about medical testing). We illustrate this trajectory with sample questions from our instrument.

Introduction

The National Institutes of Health (NIH, 2016) claims that “Health risks can sometimes be confusing, but they’re important to understand. Knowing the risks you and your family may face can help you find ways to avoid health problems. It can also keep you from fretting over unlikely threats.” Risks, often communicated in numeric formats (as percent or relative frequency), fall into the domain of health numeracy. Proficiency in numeracy has “demonstrated a positive association with communication and medical care outcomes including greater understanding of health information and risk statistics.” (Schapira et al., 2004).

Inadequate numeracy is a serious problem. Canadian Council of Learning reported that “60% of adults in Canada lack the capacity to obtain, understand and act upon health information and services and to make appropriate health decisions on their own” (CCL, 2008). Assessing the numeracy among medical professionals, Wegwarth, Wagner, & Gigerenzer (2017) write: “Many physicians do not know or understand the medical evidence behind screening tests, do not adequately counsel (asymptomatic) people on screening, and make recommendations that conflict with existing guidelines on informed choice.” Highlighting the tension between researchers in health sciences and health

practitioners, Barraclough (2004) criticizes the presentation of statistical arguments in research papers: “How many doctors have a clue what it means? Of all the areas of mathematics, probability, and its inscrutable daughter statistics, are the most slippery to grasp.”

In order to address numeracy in a range of health-related contexts, we decided to build an online teaching and learning instrument, aimed at health care professionals, students in health-related fields, patients and their families, and, hopefully, general population.

Online Teaching and Learning Instrument

Our teaching and learning instrument (TLI) was built on the conceptualization of health numeracy that we developed (Gula & Lovric, 2019), based on existing literature about (health) numeracy and health literacy, and on examining manuals, brochures, info-sheets and other documents that are used to communicate health-related information.

Borrowing the structure from the language app Duolingo (<https://www.duolingo.com/>), we divided the health numeracy material into small units (lessons), which are designed in such a way that a user can complete one lesson in five minutes or less. Each lesson addresses a single topic or a single idea, and consists of five to ten questions. A user learns by reflecting and attempting to answer each question, and then by reading feedback provided as part of the answer.

In terms of its digital life, the didactical functionalities of our TLI are: the function of learning environment for practicing skills; and the function of learning environment for fostering the development of conceptual understanding (Drijvers, Boon, & Van Reeuwijk, 2010). As health care professionals, patients, and their families are among the intended users of the TLI, our design needed to align with the principles of adult learning, as outlined, for instance, in Griffiths & Stone (2013). The probabilistic content needs to be learned “in context for a specific purpose; reason for learning is to solve a problem/ apply it” (Brooks, 2013, p.142).

Teaching Probability

Given the diversity of the backgrounds, knowledge and demands of our intended users, we built a trajectory from the basic principles, to dealing with data uncertainty, which is “one of the most difficult aspects of risk communication” (Ahmed et al., 2012), to explaining conditional probabilities and the law of total probability (needed in reasoning about medical testing) - with minimum mathematics possible (which means no formulas nor symbols), and always in concrete situations.

We assumed that a typical user of our TLI does not possess algebraic competencies (e.g., working with math symbols and formulas), nor has time or means to take course(s) to learn about it. Our major challenge has been the fact that although adults do need a good understanding of major probabilistic ideas, that understanding should not come from formal definitions, theorems and algorithms, as in mathematics courses. We kept in mind

that, as probabilistic reasoning is not intuitive (Kahneman, 2013), we had to build that intuition, starting with common-sense reasoning about familiar situations and models.

Our TLI organizes thinking about uncertainty, risk and chance into four units: *Introduction to probabilistic models*, which relies on user's intuition to discuss basic probabilistic ideas; *Probability and risk in health: Intuition and concepts*, where the intuitive models from the previous unit are transferred to health-related situations; *Calculating probability and probabilistic reasoning*, which further develops the probability, to include concepts of independence, conditional probability, and contingency tables; and *Narratives involving probability, chance and risk*, where the user tests their probabilistic understandings within authentic contexts.

Sample TLI Questions

A good way to illustrate our TLI is to discuss a sample of questions selected from the probability units.

Before reaching probability, a user gains proficiency in thinking about basic relations between numbers, including ratio and percent. Within probability, this proficiency is employed to answer the following question: "The risk of side effects of a medication used to treat human papillomavirus is 4 out of 10 for women and 4 out of 15 for men. True or false: Women who use this medication are less likely than men to experience side effects."

This kind of a question is widely used in testing numeracy skills; see, for instance, *Objective Numeracy Scale* in Lipkus et al. (2001). Related to this scale is the following fill-in-the-blank question: "About 3 in every 5 patients who take antidepressants experience side effects. The chance that a randomly selected person on antidepressants will experience side effects is ____%." Besides probing user's knowledge about ratios and percents, this question brings together two ways in which probabilistic information is presented: as a relative frequency and as a percent (alternative ways include graphs and diagrams). The decision about which of the two frames to use is essential in effective communication of risk (Gigerenzer et al, 2006).

The following question, based on Veenstra et al. (1999), is about the risk of side effects: "Steroids are associated with numerous side effects that lead to increased patient morbidity and mortality: [...] the incidence of steroid-related hypertension (15%), post transplantation diabetes mellitus (10%), peripheral fractures (2%), avascular necrosis of the hip (8%), and cataracts (22%)." The user is asked to identify which side effect is the most likely to occur.

Evidence suggests that an average person finds the numeric information given in this quote confusing, and has difficulties ranking the risks (which side effect is the most/ least likely to occur?). In this case, a more productive approach (Gigerenzer et al., 2006) would be to use the relative frequencies. However, this is prone to misinterpretations as well. Fuller et al. (2002) write: "quoting a risk of death of one in five (that is 20%) might be interpreted by a patient as 5%, altering their decision to undergo treatment with

potentially fatal consequences. Similarly, a one in 20 risk interpreted as 20% might dissuade a patient from choosing a potentially beneficial intervention.”

What does 25% really mean? It means 1 in 4, but that does not answer the question. If the chance of picking a red ball from a box of coloured balls is 1 in 4, does it mean that if we pick four balls, one will be red? The answer is – it does not have to be. However, as we keep repeating the experiment (one thousand, one million times, etc.), the ratio of red balls that we pick will be getting closer to 1 in 4.

Here is a question from our TLI that tests this understanding: “About 25% of people with diabetes have high blood pressure. We randomly select a group of people with diabetes. Which of the following is the *least likely* to occur?

- a. In a group of 4 people with diabetes, 1 has high blood pressure
- b. In a group of 40 people with diabetes, about 10 have high blood pressure
- c. In a group of 400 people with diabetes, about 100 have high blood pressure”

The correct answer is a. The explanation to this question (which a user can access irrespective of whether they answered correctly or not) includes the key fact that larger samples show smaller deviations from expected values; i.e., as the group size decreases, the difference between the expected and actual values increases.

Given that most health care professionals are not familiar with mathematical formulas, the approaches to certain topics in probability need to be reworked. That is the case of Bayes’ formula and the Law of Total Probability, which require conditional probability. A typical scenario where these mathematical tools are needed concerns the case where the prevalence is known (such as “1 percent of patients suffer from some disease”), together with information about the false positive/ false alarm rate (if a patient does not have the disease, the false positive is the probability that they nevertheless test positive) and sensitivity (if a patient has the disease, the sensitivity is the probability that they test positive; from this information, one can derive the false negative rate).

The approach we took for the TLI is to teach a user, through a sequence of lessons, how to create a contingency table based on the given data. Once this is accomplished, answering the important question – what is the chance that a person who tested positive for the disease, actually has it – is reduced to looking up the numbers in the table, and, understanding what they mean, performing simple algebraic operations. As well, by building a contingency table, users can investigate how the answer to the question above depends on the prevalence (which is essential in interpreting test results).

To see how the entire TLI is organized, and to experience it, please visit bit.ly/henupr.

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Numeracy as a UN Sustainable Development Goal: Some personal reflections on what this may mean for adults learning and using mathematics in a Digital Age and for their educators

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In this session I will offer some personal reflections on what the inclusion of “numeracy” for the first time in the United Nations’ ambitious Sustainable Development Goals (SDGs), adopted in 2015, may mean for adults learning and using mathematics in a Digital Age and for their educators. The SDGs aim to end poverty, promote prosperity and well-being for all and protect the planet by 2030. SDG Target 4.6 states that “By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy”. I am a member of the expert group convened by UNESCO’s Institute for Lifelong Learning to consider how to monitor progress towards this target. The intention is to produce a conceptual framework to enable comparison of results across countries and a concrete definition of “proficiency levels”. I shall present my reflections on work in progress on this complex and challenging task.

Introduction

For the first time, “numeracy” is specified in the United Nations’ Sustainable Development Goals (SDGs) adopted in 2015. The SDGs replace the UN Millennium Development Goals 2000-2015 and Education For All (EFA) and aim to complete what they did not achieve.

The 17 SDGs are a hugely ambitious statement of aspirations, voluntarily agreed by all UN Member States, not a binding treaty. The SDGs aim to end poverty, promote prosperity and well-being for all and protect the planet by 2030. SDG 4 aims to “Ensure inclusive and

equitable quality education and promote lifelong learning opportunities for all”. Within that, SDG Target 4.6 states that “By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy” and SDG Indicator 4.6.1 states that “Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex”.

The UNESCO Institute for Lifelong Learning (UIL) has convened experts to address measurement issues in producing data for SDG Indicator 4.6.1 in support of the Global Alliance to Monitor Learning (GAML). The intention is to produce a conceptual framework to enable comparison of results across countries and a concrete definition of “proficiency levels”. I am a member of the Expert Group.

Method

In this session I will offer some personal reflections on what this may mean for adults learning and using mathematics in a Digital Age, and for their educators, and consider how to monitor progress towards SDG 4.6.1, given that 48 percent of people worldwide use the internet, according to 2017 statistics (Rosling, Rosling & Rönnlund, 2018), so “the proportion of people with access to the internet is not large enough to represent the whole population” (Rönnlund & Rosling, 2018).

I shall draw on reports of expert deliberations and discussions convened by UIL, together with other sources. Key proposals of the Expert Group’s meetings to date are as follows:

- To adopt the UNESCO working definition of literacy (2005) for indicator 4.6.1;
- To use the PIAAC conceptual framework as a basis for developing a global framework for indicator 4.6.1;
- To measure literacy and numeracy separately;
- To focus on reading as the domain for global comparability for literacy. Writing, which was considered as an integral component of literacy skills, could be assessed at the national level;
- To develop global reporting frameworks to cover the lower levels of the literacy and numeracy skills spectrum (below PIAAC level 1 as a reference point).

Findings/Expected findings

I shall present my reflections on work in progress on this complex task; it is premature to speak of findings or expected findings.

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Mathematics at Work: Interdisciplinary translational research in Healthcare Numeracy

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In this session I present my ongoing translational research on healthcare numeracy as part of an interdisciplinary team aiming to define and propose a healthcare numeracy benchmark in the safety-critical context of Nursing and Midwifery.

Introduction

I outline some current thinking on healthcare numeracy as an instance of vocational mathematics, drawing on my experience as a member of an interdisciplinary international team undertaking long-term translational research on healthcare numeracy education with the aim of defining and proposing a healthcare numeracy benchmark in Nursing and Midwifery.

Method

Our 28-year translational research programme on drug dosage calculation and healthcare numeracy using a variety of methods is summarised in Coben and Weeks (2014) and explored more widely in the Nurse Education in Practice, Safety in Numbers series (various authors, 2013, <https://www.sciencedirect.com/journal/nurse-education-in-practice>). Our recent research is outlined in Weeks, et al. (2019) 'Developing and integrating nursing competence through authentic technology-enhanced clinical simulation education: Pedagogies for reconceptualising the theory-practice gap'.

Findings/Expected findings

I present 'the story so far', updating previous presentations on this topic to successive ALM conferences, e.g., Coben 2018 (ALM-15); Coben & Weeks, 2018 (ALM-19); Coben, Sabin, et al., 2018 (ALM-14).

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Using digital technology in mathematics teaching within English vocational education

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Digital technology has been viewed as a cultural revolution with the potential to transform education but its place in English post-16 education has been less prominent than anticipated. This paper explores the uses of digital technology to support the teaching of low-attaining students in post-16 vocational education by examining findings from the Mathematics in Further Education Colleges (MiFEC) project. These findings are drawn from case studies of over 30 colleges and are analysed for this section of the research in relation to three identified linked strands in the use of technology (Fullan and Donnelly, 2013). Both benefits and challenges of using digital technology in this context are identified. The pace of local system change and distinctive characteristics of the student cohort affect practice but under-developed pedagogies are also evidenced. This analysis will provide a foundation for discussion about similar or contrasting challenges in other educational contexts and countries.

Introduction

Digital technology has been viewed as a cultural revolution with the potential to transform education (Vander Ark, 2011). Although digital technology is ubiquitous in the lives of young adult students, its place in education has been less prominent than anticipated in England (Fullan and Donnelly, 2013). Evidence of positive benefits has been unclear due to the wide variety of technologies and contexts (Higgins et al., 2012) and there is limited evidence of the impact of specific technologies on learning, such as tablets (Hassler, Major and Hennessey, 2015). One reason suggested for the lack of progress is the unequal development of three essential linked strands, which Fullan and Donnelly (2013) identify as 1) the technology itself, 2) appropriate pedagogies and 3) the necessary system change.

In this paper, the uses of digital technology by teachers in post-16 vocational education are explored, drawing on findings from the Mathematics in Further Education Colleges (MiFEC) project. The paper focuses on how technology is used to support the teaching of low-attaining students, who are required to continue studying mathematics until they reach a certain minimum standard, and aims to identify both the benefits and challenges of using digital technology in this educational context.

Method

The MiFEC project consists of four interlinked strands of research about mathematics policy and practice. For the purposes of this discussion, only the relevant findings from the case study strand of the project are presented. These case studies involve over 30 Further Education (FE) colleges. FE colleges are the main providers of vocational education in England and the colleges selected for the research form a balanced sample across the nine regions of the country. Individual interviews with teachers and managers and focus groups with students took place in each college and transcripts were analysed using open coding to identify emerging themes. Further examination of the teaching and learning theme was carried out using secondary coding, leading to a consideration of how the three linked strands identified by Fullan and Donnelly (2013) are evidenced in mathematics teaching within this sample of FE colleges.

Findings

Our analysis shows that the use of technology in mathematics teaching includes a range of programmes and apps but their use is constrained by limited access to hardware and the unreliability of systems to support learning in some colleges. Overall, the use of technology in lessons is small compared to other teaching approaches, but colleges do use technology widely for initial assessment, tracking student progress and providing resources for independent student work or extra support outside class. Not all these strategies are however having the desired effect on students' learning of mathematics.

The technology used in the classroom mainly involves tools such as the students' mobile phones or computer suites within college. Some teachers report challenges with allowing students to use mobile phones since mathematics learning activity quickly strays towards unconnected use of social media. Mathematics is rarely timetabled in computer suites on a regular basis and, although these are available in college, they are not always easily accessed through college timetabling systems. In some college buildings teachers also report slow Internet connections. These limitations of college systems illustrate the constraints when local system change is not keeping pace with the educational potential that the technology affords.

Most colleges also have extensive resources available to students on a range of platforms for further independent learning and extra support. These resources are sometimes used in lessons but more commonly they are made available for independent work outside the classroom. Three issues that indicate the limitations of this approach emerge from the study. First, many of these students have little motivation to study mathematics and therefore do not engage with any learning of mathematics outside the classroom, with or without these resources. Secondly, teachers report that many of these young adults still lack the maturity and skills to study independently, so self-directed learning is not always effective. Thirdly, some students voiced strong opinions about their dislike of the programmes available electronically and stated their preference for face-to-face explanations from their teacher. The use of technology in teaching and learning is therefore rendered less effective than intended, due to assumptions about how students' will interact with the technology inside and outside the classroom.

The most widespread use of technology evidenced in the study was the use of electronic systems, by which teachers assess and track student progress. These are clearly an essential aid, by which teachers identify students who need extra support. This often leads to targeted interventions to support students, although in some cases it also generates a volume of data that teachers cannot usefully process.

These examples of how technology is used in mathematics teaching and learning represent a narrow selection from the tools available that can open up new windows to understanding or mediate students' learning pathways (Hoyles and Lagrange, 2010). Although systemic issues and characteristics of the student cohort affect the impact on learning within this educational context, evidence of the under-use of technology in this study also suggests a need for professional development that equips teachers to utilise effectively the resources available.

Summary

The use of technology in education promises a revolution in teaching approaches but there is greater potential for a positive impact on learning than is currently being realised. Our analysis of the current situation in post-16 education in England, based on empirical evidence, suggests a number of constraints arising from under-developed pedagogical approaches and characteristics of the student cohort. This session will provide an opportunity to discuss these challenges in the context of other learning situations and make comparisons across countries.

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Digitizing the Learning of Numeracy... a report from the trenches of the Health Numeracy Project

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The process of digitizing the learning of numeracy requires that an appropriate analogue version exists. Despite Lynn Arthur Steen's (Steen, 1990) and others' recognition that changes in technology would necessitate new approaches to numeracy, including what is taught, very little has changed in the content of foundations mathematics (mathematics for the non-mathematician) courses in Canadian Community Colleges and Universities, where the learning of numeracy is supposed to take place.

This report takes the need for us to do better as a starting point and presents a conceptualization of numeracy which is not new, but which can act as an effective thinking tool to critique current practice and inform instructional design whether it be in the analogue or digital formats. The conceptualization sees mathematics and numeracy as distinct, though related, activities, with number sense as a core competency. Finally, we use the conceptualization to design learning content and begin to expose those elements of numeracy that remain elusive.

Through the Health Numeracy Project, we have had the opportunity to explore tensions between educational theory and practice, teaching and learning, mathematics and numeracy, as well as digital and analogue learning. The most difficult aspect has been the design and construction of the on-line learning instrument as the format and content continue to evolve in fits and starts as we learn more about analogue numeracy in the health context, and about how individuals use digital tools as aids in learning. We hope that you keep this *work in progress* aspect of the project in mind as you read through our report, and as you investigate the teaching and learning instrument (bit.ly/henupr) developed for the Health Numeracy Project.

Analogue Numeracy in Ontario, Canada

Since the 1960s the conceptualization of numeracy has been challenging educators to think differently about math education, and the connection between mathematics and the 'real world', but the myriad of definitions have been difficult to operationalize for teachers and instructional designers. Though many see numeracy as math basics or

mathematics lite (Kaye, in Griffiths (2013) pg. 64), more sophisticated conceptualizations demand a clarification of the relationship between mathematics and numeracy, and involve social, emotional, dispositional and other aspects of individuals as key elements of numeracy (Goos et al, 2010). Maguire and O'Donoghue (2003) proposed an organising framework of numeracy concept sophistication, which describe 3 phases of numeracy: Formative, Mathematical and Integrative. They placed Canada in the formative phase (i.e. focus is on functional skills limited to basic arithmetic set in everyday contexts). Unfortunately, today, 16 years later, we have not seen the policy and curriculum changes that challenge this placement.

Our experience with foundations mathematics course curriculum in the Ontario college context, shows that although there have been calls for fixing an extensively researched numeracy gap (Orpwood & Brown, 2015), in practice the focus of numeracy endeavours remains on calculations and procedural arithmetic.

Exhibit A: the numeracy gap identified a need for a common assessment, and in its development the following “numeracy” topics were identified: Order of Operations, Fractions, Decimals, Percentages, Ratio & Proportion, Algebra and Exponents (Orpwood & Brown, 2013). For example, we present one of the five sample assessment items in the new Ontario College Math Test (2017) developed in response to the numeracy gap:

$$21 \div 7 \times 11^2 + (12 - 5)^2 \times 2 = \underline{\hspace{1cm}} \square$$

This item, and their use of the terms mathematics and numeracy interchangeably in practice indicates that at the college level we have a lot to do.

Exhibit B: the Ontario Ministry of Training, Colleges and Universities (2019) lists only one learning outcome under numeracy as an essential employability skill: execute mathematical operations accurately.

Actions demonstrating a more sophisticated view of numeracy have been noted. In 2016 and 2017, the Higher Education Quality Council of Ontario (HEQCO) conducted the Essential Adult Skills Initiative, using a much more ambitious and sophisticated approach to numeracy. 19 Ontario colleges and universities, and one out of province university participated (Weingarten, 2018). HEQCO used a PIIAC based assessment of numeracy and literacy called the called Education and Skills Online (ESO). They found that too few graduating students demonstrated superior skills, and that there was a relatively minor skill gain between first year and graduation, that demands further research (Weingarten, 2018). The finding of minor skill gain echoes the work of Arum and Roksa (2011) in the United States. The need to do better is clear.

We need to do more than just teach and assess basic procedures in order to help individuals become more numerate. What exactly does that mean for those of us teaching adults foundations mathematics/numeracy in post-secondary health sciences programs?

Numeracy as Distinct from Mathematics

The tension between mathematics and numeracy has been a key area of exploration in the theoretical work of the Health Numeracy Project. Is one a subset of the other? Are they different modes of thinking? We believe that it is this tension, that continues to keep numeracy as an ill-defined concept, despite the excellent theoretical work and many complex conceptualizations of numeracy.

PIAAC's (2009) focus on numerate behaviour, stating that it *involves managing a situation or solving a problem in a real context, by responding to mathematical content/information/ideas represented in multiple ways* with a detailed breakdown of each aspect of the conceptualization provided an excellent start. Nevertheless, we decided that the following was much more helpful in our instructional design, without straying from PIAAC's conceptualization.

In quantitative literacy, numbers describe features of concrete situations that enhance our understanding.

In mathematics, numbers are themselves the object of study and lead to the discovery and exploration of even more abstract objects. (Manaster, 2001)

Using this as a lens, or thinking tool (Dennett, 2018), echoes Willis' conceptualization of numeracy as 'strategic mathematics' (Willis, 1998) and allows one to see learning-doing mathematics and learning-doing numeracy as distinct activities, and thus distinct competencies. We have developed a short-hand for defining these sets. Learning-doing mathematics can be seen to involve thinking *about* numbers, while learning-doing numeracy can be seen to involve thinking *with* numbers.

Adopting Manaster's approach in designing expectations for numeracy in a health context would require 3 separate activities for the user and corresponding design objectives:

- Strengthening thinking about numbers and other mathematical objects requires that the designer conducts a thorough analysis of how much mathematics is needed for the health context (the relatively easy part),
- Strengthening thinking with numbers in simple health contexts requires designers to review the health care specific language and terminology (health literacy),
- Strengthening what Schoenfeld (1990) refers to as sense-making ability, which can reside in mathematics as well as in the concrete world. (a much more elusive form of reasoning).

Although we have found that making a distinction between mathematics and numeracy is valid and useful for our work in critiquing current practice with adults and developing our on-line learning instrument, we wonder whether the same would be true for secondary and elementary math education?

Theoretical consequences of Manaster's conceptualization

- Numeracy does not exist out of context. Someone numerate in the health context may not be numerate in the world of business and finance as the mathematics needed and the knowledge of the context are key to being numerate.
- Math problems must be about mathematics and build knowledge of mathematical objects and their relations. 'Real world' word problems must be about building understanding of the concrete situations in which they reside.
- In a pedagogical setting one still can use the concrete to build understanding of the abstract... the key is the about-ness.
- There is no contradiction with activities like mathematical thinking, sense-making and mathematizing. These are all important competencies that remain at the core of mathematics education and numeracy.

From Theory to Practice – Instructional Design for Digitization

Manaster's conceptualization has provided the Health Numeracy Project a solid theoretical foundation from which to develop learning content necessary (but not necessarily sufficient) for numeracy in the health sciences context.

Our parameters and constraints:

- We are not aiming to help people become better mathematicians, or develop new abstract thinking tools.
- We are aiming to strengthen competencies that may be needed in a health context for health science students, practitioners, patients and patient educators.
- We are constrained by and blessed by working in a digital on-line format. Constraints come from not having a face to face interaction with the user, nor of the user with other users. Blessings come from the ability to provide immediate feedback to the user, and to develop interactive visualization tools that can help build competencies that will lead to comprehension.
- Calculation based arithmetic is to be kept to a minimum. Force the user to slow thinking (Kahnemahn, 2011) rather than simply recall.
- No didactics except through feedback. Constant challenges in scaffolded competencies are key to helping individuals strengthen their ability to use thinking tools in the given topic.

Our audience includes a large majority of adults who struggle with health care decisions, and have already been exposed to school mathematics, thus a review, or

perhaps re-discovery of number sense is a necessary precursor to success at making sense of the health care world using numbers.

Number Sense as a Foundation for Adult Numeracy

What mathematics and how much mathematics are needed (by adults) to be numerate depend on the context that one is preparing for. The content of our web-application is rooted in some excellent work from psychology, math education and health numeracy (Ancker, 2007; Dehaene, 2011; & McIntosh, 2005) which together support the view that strong number sense provides a necessary and possibly sufficient mathematical foundation for being able to navigate concrete situations – in the health context. We identified two levels of mathematical competencies (thinking about numbers) necessary for a numerate adult operating in a health sciences context.

- Intuitions about numbers and their relations (which involve basic arithmetic, visualization and part-whole thinking)
- Conversions (which involve the recognizing and thinking about positive rational numbers and the various formats in which they may be presented)

Thinking about numbers involves many individual competencies that we have packaged as lessons within topics and designed to be scaffolded from simplest to more complex. At the time of writing there are over 150 lessons in the Intuitions level, and over 110 in the Conversions level. These comprise the extent of strictly mathematical content we identified as necessary for being numerate in most health care settings.

Learning About the Health Care Context

The shift from thinking *about* numbers to thinking *with* numbers involves a shift from abstract to concrete problems. The focus of learning content then must be on developing competencies that are necessary for bridging between the two. We have developed two levels of competencies which aim to do just that. We have placed these under an umbrella called ‘Breaking the Code’ since for the most part concrete situations do not present themselves with simple pre-packaged solutions. Breaking the code involves being literate in the concrete situation in which one must solve the problem, and recognizing the ways that information is presented. We have organized these into the following disparate competencies:

- Measurements and Units (understanding a wide variety of measures and metric units and converting between them).
- Classify, Read and Interpret charts, graphs and written health care information.

Uncertainty, Chance and Probability

Focus is on the concrete situations that involve uncertainty and chance and that evoke probabilistic reasoning. This level stands alone as one that involves a specific form of

reasoning and is described in more detail in a separate report in these Proceedings (Burazin et al, 2019)

Health Numeracy and Citizenry

Living as a well-informed citizen in the 21st century Canada requires both knowing certain numeric facts and the ability to understand, interpret and communicate quantitative health care related information. Two units have been developed to do just that.

- Breaking the Code: Health (reading information from a variety of sources and using the information to answer questions about nutrition, fitness, the environment, demographics and social determinants of health)
- Numbers in the World (a collection of numerical facts about the world, environment, society, and human body and health that a Canadian should know e.g., The USA has 10 times the population of Canada).

Beyond the Basics

In this paper we discussed the learning content which, supported by research evidence, we deem to be *necessary* for understanding health numeracy. We recognize, however, that it *might not necessarily be sufficient* for many individual health care practitioners and patients. There has been much work done in areas like problem based learning that aims to strengthen learners' ability to work with open-ended or ill-defined problems, to use the kind of informal reasoning that Schoenfeld (1990) calls 'sense-making,' many others call 'critical thinking,' and Kahneman (2011) calls it 'system 2,' or 'slow thinking.' Designing analogue and digital exercises for individual practice of these competencies requires much more nuance and sophistication. We expect that, having established exercises that help strengthen core competencies of health numeracy, we can now start working on the more elusive complex reasoning, and look forward to ongoing conversations on how to make that happen.

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Numeracy in Situations of Vulnerability. Emancipating Numeracy Practices in Situations of Over-Indebtedness, Living with Learning Difficulties and in Older Age

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How important is numeracy in our everyday lives? Which role does numeracy play for vulnerable subgroups? In the Hamburg Numeracy Project, six research projects are looking into these questions. Each research project focusses on a specific subgroup or a specific type of vulnerability (e.g. adults living in over-indebtedness, seeking refuge, in higher age or with learning difficulties). We are using Large-Scale-Assessments like the Survey of Adult Skills (PIAAC) to determine general factors for and circumstances of vulnerability and their relation to numeracy. The separate research projects conducted group and single interviews, undertook participatory research workshops, observed learning situations, and everyday situations.

Introduction

The Hamburg Numeracy Project is a joint project of six different chairs in four institutions, all set in Hamburg. The project looks at different social groups or situations that are often seen and described as vulnerable. We analyse the role numeracy practices play in their lives and in these vulnerable situations.

The concepts of numeracy and vulnerability are often closely connected. Numeracy is supposed to protect against vulnerability; people and societies benefit from investing in numeracy education (Craig, 2018). We understand numeracy (as well as mathematics) to be socially constructed, to be embedded in social relations, in context, and values (c.f. Baker 2006). We conceptualise vulnerability as an increased risk of exclusion on the one

¹ Further researchers in the project are: Katharina Angermeier, Harald Ansen, Melanie Benz-Gydat, Wiebke Curdt, Anke Grotlüschen, Hanna Gundlach, Gabriele Kaiser, Huacong Liu, Maike Lüssenhop, Antje Pabst, Alina Redmer, Silke Schreiber-Barsch, Christine Zeuner.

hand, and as a public responsibility not to marginalise certain groups on the other. We see and use vulnerability not as an characteristic of an individual or a group but as a focal point for analysis (c.f. Hurst 2008).

While digital challenges were not originally a focus of our research, new and changing digital and technological challenges and questions emerged in the research. Mathematical aspects of everyday challenges become more and more invisible due to the demathematising effect of technology (Jablonka & Gellert, 2007) – with ambivalent consequences. Technologies (e.g. for budget planning) facilitate mathematical tasks. At the same time, it becomes easier to lose track of one's financial situation (Angermeier & Ansen, 2019, p. 3). In addition, the invisibility and implicitness of numeracy practices in most of our lives (Coben, 2002), might make it more difficult to see and acknowledge numeracy practices and skills. This may pertain to - for example - people with learning difficulties, or to (post-)war generations who have had interrupted educational careers. They have to learn how to deal with technological changes, which can be a support but also an additional challenge. When reaching retirement age, many of them are faced with big live changes and new numeracy-related challenges to which they have to find answers. This presentation will present the preliminary findings of four subprojects who focus on three specific questions around vulnerability and numeracy using quantitative and qualitative approaches:

- (1) Which relevance and meaning do people of the war and post-war generation attribute to numeracy?
- (2) What role do numeracy practices play in the everyday lives of adults with learning difficulties?
- (3) Can numeracy skills be a protection against and/or a way out of over-indebtedness?

Methods

Different methods and methodologies are used to find answers to these research questions. Multiple research projects inside of the Hamburg Numeracy Project investigate these questions in qualitative as well as quantitative approaches. Focussing on a social environment, interviews with people in older age are carried out. Two group interviews with professionals in debt counselling started the research on over-indebtedness. They will be followed by several individual interviews with over-indebted people. To learn about numeracy practices of adults with learning difficulties, a participatory research design was chosen (c.f. von Unger, 2012). In a participatory

research group, which included nine adults with learning difficulties, the general process, as well as the used wording, were determined. After that, eleven adults with learning difficulties were accompanied through their everyday life by the researchers. For quantitative secondary analyses, three main sources of data are used: The Programme for the International Assessment of Adult Competencies (PIAAC), Curriculum und Professionalisierung der Finanziellen Grundbildung (CurVe), and Competencies in Later Life (CiLL).

Preliminary Findings

Overall, the preliminary findings affirm an emancipatory potential of numeracy practices. Adults with learning difficulties can gain moments of autonomy and control. Numeracy practices are not in of themselves a protection from becoming over-indebted. However, numeracy practices might be helpful to overcome debt and over-indebtedness. These numeracy practices need to be accompanied with relevant context knowledge. The interviews with people of an older age indicated that they see numeracy as less relevant, especially when compared to reading and writing, but at the same time, they rely heavily on their numeracy practices to handle everyday challenges.

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Adult numeracy practices: imperative implications for education

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In this paper we explore the demands that our current society places on the numerate behavior of individuals and argue that numeracy education should take this behavior as starting point. After a short historical introduction, we will introduce a framework (under construction), which aims at establishing a broad consensus in Europe on a common language to discuss, define, describe, and teach numeracy.

Introduction

The picture in Figure 1 is by some researchers considered to be one of the he first examples of human numerate practices in "writing".



Figure 1: <https://www.schoyencollection.com/24-smaller-collections/wine-beer/ms-1717-beer-inanna-uruk>

It is a Sumerian pictographic script from the 31st century BC on a tablet, which is part of the Schøyen collection in Norway. The tablet is presumed to be giving information on the production of beer 5000 years ago. Reading from right to left, we see the barley delivered, then the brick building - presumably the brewery -, and the barley in the jar resulting in the beer. It is the earliest representation in history of an industrial process. Looking at this tablet from a mathematical perspective, we see that the use of quantitative notations is meaningful and purposeful. For the documentation of the brewing process an external tool is used in this tablet. And a mix of cognitive tools is used: pictorials, quantities and order of process.

So, using schematic, symbolic, quantitative and visual notations to describe the real world and to communicate with others, which is mathematics, is as old as the written language of the first civilized societies. It is good to remember that we as mankind have used symbols and other visual representations to describe and control the world for millennia, basically as long as we have had civilized societies.

If we look at it more closely at the history of this and the last century, we see in different decades a different focus on what is relevant for individuals in their mathematical repertoire when dealing with daily (quantitative) problems. See Figure 2.

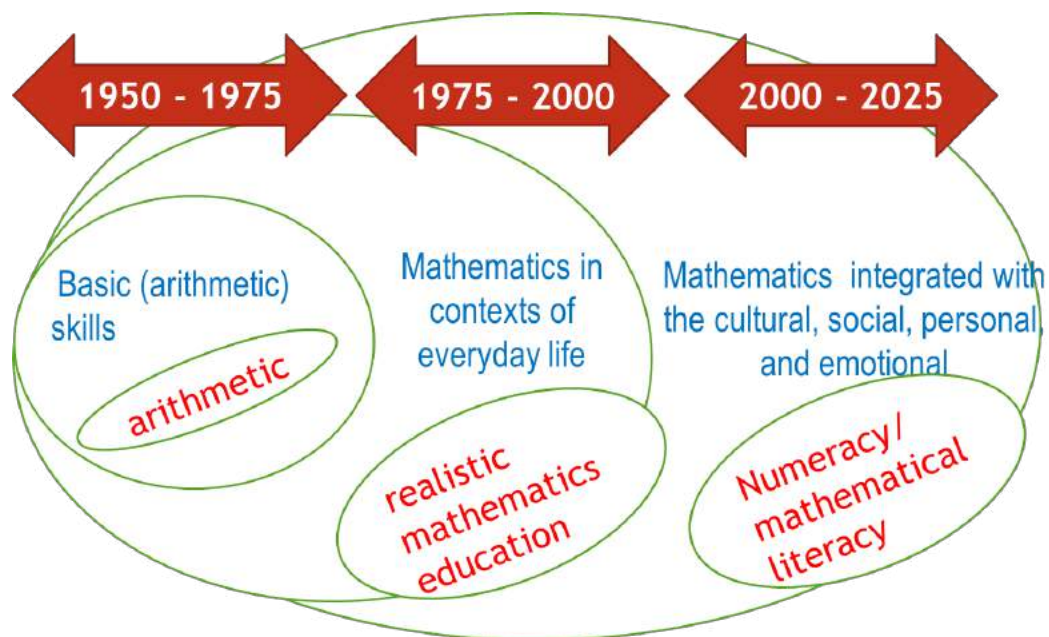


Figure 2: Relevant mathematics for use in daily life (Hoogland, 2018)

After WWII, in the third quarter of last century (1950-1975), there was a broad consensus that the best way to prepare students for the needs of society should consist of practicing

operations on bare numbers according to fixed procedures by hand and on paper: algorithms for adding, subtracting, multiplying and dividing. Long division is the iconic image of this perspective. Was that a relevant activity? Yes, very relevant. Before 1975 there were simply no calculators and everything, really everything, had to be calculated by hand and with pen and paper. Every factory built in the reconstruction of society after WWII, every rocket shot to the moon, every conveyor belt production process was created by engineers who carried out complex calculations with pen and paper. But also all retail transactions were based on manual calculations. However, the quantitative side of the world today looks very different and the actual computing by pen and paper has for a significant part lost its relevance.

In the fourth quarter of last century (1975 – 2000) all kinds of mechanical and electronic tools made their appearance which made manual work for a large part superfluous: calculators, electronic cash registers, spreadsheets, et cetera became part and parcel of daily life activities. In education, the desire arose not only to learn the pen-and-paper skills, but also to teach where and how these skills could be used to solve problems from daily life. Situations from reality became part of education in many forms, such as: applications, simulations, contexts, projects. The emergence of Realistic Mathematics Education (see Van den Heuvel-Panhuizen, 2020a, 2020b), for instance, is an example of this perspective. By the way, this was not a completely new idea; Willem Bartjens' book on arithmetic *De Cijfferringe*(1604) is also packed with commercial arithmetical problems, which were practical tasks of great societal relevance. Between 1600 and 1800 the book easily reached its hundredth edition. However, bringing reality into the classroom is not always easy for teachers and schools. In many situations it is reduced to making assignments for the textbook, in which real situations are described by words: word problems. In the last century, in education the use of context, was actually the same as using verbal descriptions of reality. This of course created problems of it's own.

In the first quarter of this century (2000-2025), a third perspective on numeracy is rapidly gaining popularity worldwide. From this perspective students have to be “numerate” in order to deal with the quantitative side of the world. See Figure 2. Numeracy takes the person and his/her relationship with the world as a starting point. The quantitative side of the world is so rich, so varied and sometimes so complex, that people need a very extensive repertoire to cope with it. From this perspective, numeracy is an inseparable part of personal development. Immediately after birth, the first interactions of the young born with numbers, patterns and structures in time and space, are discernible. Our brains are said to be hardwired to deal with numbers, structures and patterns (Butterworth, 1999; Devlin, 1996). The body supports numeracy development by moving around and interacting with the three-dimensional physical environment.



Figure 3: Elements of the numerate world in the 21st century

Interest in the psychological side of mathematics learning is also increasingly the subject of study. Many difficulties student have with mathematics and numeracy can be associated with psychological problems caused by educational settings of selection and strict right/wrong regimes (see for example the literature on math anxiety (Dowker et al., 2016). It is good to realize that math anxiety is not a student characteristic, but rather an educational outcome.

Part of numeracy is also how to deal with the avalanche of quantitative data that today's society produces and uses for economic traffic, the political process and daily life. It is about drawing conclusions from numerical information. Interpreting, analyzing, organizing, estimating, structuring, selecting and critically considering quantitative information are skills associated with numeracy. Appropriate education in this area is developing worldwide. However, the development of a functional and modern conceptualization of numeracy is slow. In politics and the (social) media, the perspective from 1950-1975 is often still dominant.

What are the aspects of the numerate world in the 21st century?

In our search for the aspects of numerate behavior in today's world, we came 'quick-and-dirty' to the following list of cognitions and manifestations (see Table 1.)

Table 1: Cognitive processes and manifestations of numerate behaviour

Cognitive processes	Manifestations
Interpreting	Product labels, advertisements, brochures....
Understanding of hidden algorithms	Apps, websites, ...
Valuating	Money, prices, ...
Measuring	Length, weight, ...
Estimating	Ubiquitous

Critical thinking	Politics, intimidation with numbers
Knowing reference measures	Body, country, world, ...
Doing calculations	By heart, when estimating By tools, when precision is demanded

The original rigorous demands of fluency in pen-and-paper computations becomes more a nice-to-have than a need-to-have. Examples from research literature on the mathematical demands of professionals are also equally broad and rich, and ranges from boat building to nurses' practices, and from managing kiwi orchards to being an airplane pilot (Coben & Hodgen, 2009; van der Wal et al., 2017; Yasukawa et al., 2018; Zevenbergen & Zevenbergen, 2009).

The concept of numeracy as a social practice

The perspective of numeracy has shifted to perceiving numeracy as a social practice. A social practice view of numeracy not only takes into account the different contexts in which numeracy is practiced, such as school, college, work and home, but also how people's life and histories, goals, values and attitudes will influence their numerate behavior. See, for instance, Oughton (2013) and Yasukawa et al. (2018).

Acknowledging that numeracy as a social practice implies taking into account that power relations can play a role in the (quality of the) numerate behavior of individuals. Examples of power relations around mathematics and numeracy education include : gate keeping and selection, inclusion and exclusion, gender stereotypes about handling numbers, formatting power (or terror) of school mathematics, intimidation by using numbers.

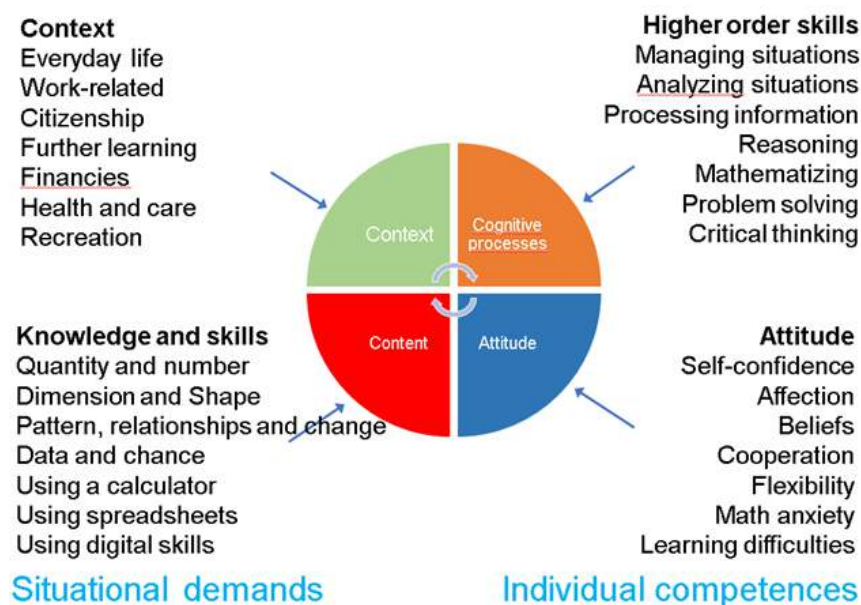


Figure 4: Aspects of Numeracy

In short we see in Figure 4 the most discernible aspects of numerate behavior, with a distinction between the more individual competences on one side and situational demands on the other side.

Numeracy education

In an Erasmus+ project of the European Union Common European Numeracy Framework, four countries, The Netherlands, Austria, Spain, and Ireland, have decided to be frontrunners in trying to translate this rich interpretation of numeracy and numerate behavior into a framework for developing numeracy education. A similar approach by the Common European Reference Framework for languages was undertaken more than 40 years ago.

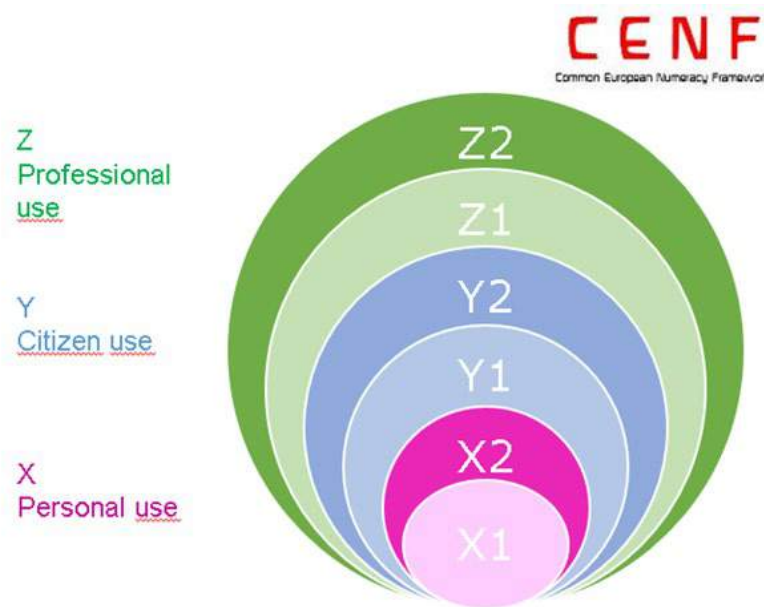


Figure 5: The six levels of the Common European Numeracy Framework

The aim of the Common European Numeracy Framework is to describe all aspects of numeracy as mentioned before (see figure 4) at three or six levels consistent with the overall categories. These descriptors will build further on the work that has been done within the worldwide numeracy community for instance around the international assessments IALS (1996), ALL (2003, 2006-2008) and PIAAC (2012, 2014) (see, for instance, PIAAC (2016) and Van Groenestijn (2003)).

This multidimensional approach gives the opportunity to characterize an individual's numeracy level on many aspects and not just on one measure, for instance a single test. The goal is to consider the many aspects that drive the quality of the numerate behavior

of individuals. To acknowledge the multifaceted nature of numeracy competences, we have to look at an individual's profile on several measures instead of just one measure. Most likely we will be looking at a very spikey profile, because adults differ immensely in their experiences and combinations of cognitive, meta-cognitive and social repertoire. Figure 6 gives a fictional multidimensional profile of the numerate level of an individual.

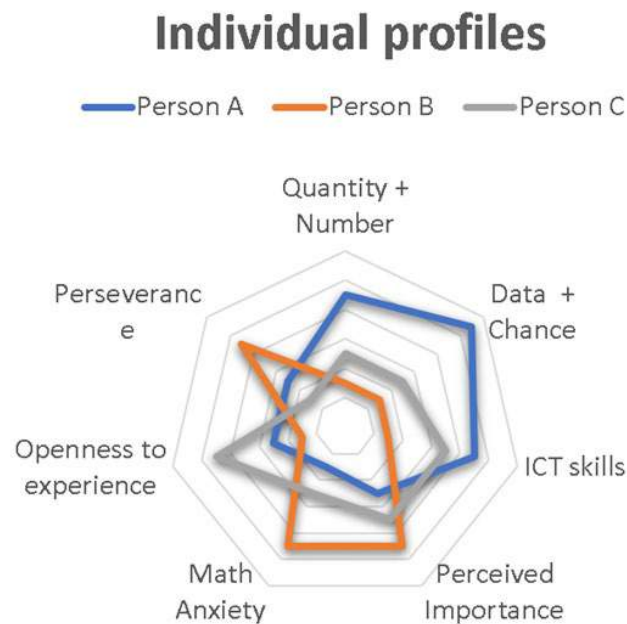


Figure6: Spiked individual numeracy profiles

Challenges for the adult numeracy community

The broad perspective on numerate behavior as sketched in this article should mirror itself in the content and methodology of numeracy courses. In the project Common European Numeracy Framework during the forthcoming years a number of professional development modules will be developed which take into account these perspectives.

In general, one could say that the following challenges lie ahead of us:

- Redefining traditional basic skills in more relevant cognitive processes and their manifestations;
- Connecting research and development to a common framework to optimize the use of collective expertise and research power.
- Systematically acknowledge multidimensionality when dealing with numeracy (in research, teaching, professional development, et cetera.)

We hope that this framework currently under construction, the first contours of which are sketched in his paper, can be a catalyst for collectively taking on these challenges.

Acknowledgement

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The Art of Looking at Public Art and Architecture with Mathematical Eyes

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This presentation is based on the ongoing project “The Art of looking at public art and architecture with mathematical eyes” conducted 2018-2019 in Sweden. The project aims to encourage math students to learn math through experiencing and exploring art and architecture in Lund. A second aim is to engage students in discovering the history and culture of their hometown. The session starts with a presentation of the project “Math-Art Walks”, followed by an introduction to art, sculptures and buildings near the conference location.

Introduction

In 2015, I participated in the ALM22 Conference in Washington D.C. having the theme “Opening Our Math Eyes To See Math In Everything We Do”. All the inspiring keynote speeches and presentations I got to take part in opened my “math-eyes” as well. Back in Sweden, I started to work out a project proposal, The Art of looking at public art and architecture with mathematical eyes. I was granted a scholarship from Gudrun Malmers Foundation and a teacher colleague, Bengt Eklund, joined the project that started in 2018.

The project aims to encourage students to see, discover and learn math through art and architecture while learning about the culture and history of their home town. In practice, this is done by “Math-Art walks” with the support of a study compendium that I developed based on the Swedish mathematics curricula (Skolverket, 2012, rev.2017), ZalayaBáez’s (2004) classification of mathematical sculpture, and art history. The relationship between art, architecture and mathematics is expressed in the aims of the mathematics curricula of adult education, compulsory school, and upper secondary school. For example, teaching mathematics in compulsory school should aim at:

helping the pupils to develop knowledge of mathematics and its use in everyday life and in different subject areas. Teaching should help pupils to develop their interest in mathematics and confidence in their own ability to use it in different contexts. It should also provide pupils with the opportunity to experience aesthetic values in mathematical patterns, forms and relationships. (Skolverket, 2012, rev. 2017).

The upper secondary curriculum in mathematics describe that:

Teaching should cover a variety of working forms and methods of working, where investigative activities form a part. Where appropriate, teaching should take place in environments that are relevant and closely related to praxis. Teaching should give students the opportunity to communicate using different forms of expression. In addition, it should provide students with challenges, as well as experience in the logic, generalizability, creative qualities and multifaceted nature of mathematics. teaching should provide students with challenges, as well as experience in the logic, generalizability, creative qualities and multifaceted nature of mathematics. (Skolverket, 2012).

My intention with the project is to visualize how integrating local art and culture in formal math education may open, not only “Math Eyes”, but “Math-Art-Culture Eyes”.

Method

As my practice is in the city of Lund, I have chosen to focus on public art and sculptures found here. All in all, the project includes 76 sculptures and buildings. To create a structure for the Math-Art Walks, the city has been divided into 20 geographical areas. For each sculpture and building, we have compiled general information about the object and tasks that, as a whole, cover many of the knowledge requirements that the students encounter in their courses. Engaging in a Math-Art Walk requires from an hour up to a day depending on how many objects are included in the walk. I have developed a compendium to be used during the walk comprising a short description of art movements, ZalayaBáez’s classification of mathematical sculptures, a set of tasks associated to each sculpture and building, and a response template.

Overall, the first and last task for each sculpture and building are identical. The first task is divided into smaller exercises. In the first, the students have to mention the name of the sculpture or building, who made it, when it was made, if it is site-specific, and what they think the artist or architect wanted to express. For the sculptures, the students also have to describe the art work with words, marking those they find mathematical. They are encouraged to identify the art movement (ism) and to find the mathematics in the object by using ZalayaBáez’s classification. The last task is to formulate a mathematical

exercise involving the sculpture or building. In between the first and last task, there are specific tasks with different mathematical content.

Lessons learned

I would be very grateful for comments that can develop and improve the project as well as your thoughts about if you could bring the concept of the project to your workplace.

The presentation

The session starts with a presentation of the project and ZalayaBáez's classification scheme of mathematical sculptures, exemplified with artwork from Lund. After that, I will go into details of one building and two public artworks in Lund whose mathematical tasks include the use of digital tools. Finally, I will show you a way to put together material for a concluding art exhibition, if you only have a few hours.

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Ten Digital-Age Decisions for Teachers of Adults Learning Mathematics

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This presentation shares ten decisions that teachers of adult mathematics learners must consider in using digital technology. These decisions involve all aspects of a teacher's role. Accordingly, an organizing framework is used which includes five areas of teachers' activities to include planning learning activities, teaching, providing feedback to students, developing learning environments, and engaging in professional development activities. Each decision involves trade-offs and each have implications for teaching and learning.

In contemplating the use of digital technology in my practice, I have found that there are some fundamental decisions that I have had to make, and indeed all teachers of adult mathematics learners must consider, regarding the use of digital technology in an adult mathematics classroom. This presentation shares those decisions, as questions, for the consideration of participants. The five Areas of Activity of the UK Professional Standards Framework (UKPSF) is used as an organizing framework. The UKPSF is managed by Advance HE (formerly the Higher Education Academy). The UKPSF can be used "for benchmarking success within HE [higher education] teaching and learning support" (Advance HE, 2018). The five Areas of Activity are (a) design and plan learning activities and/or programmes of study; (b) teach and/or support learning; (c) assess and give feedback to learners; (d) develop effective learning environments and approaches to student support and guidance; and (e) engage in continuing professional development in subjects/disciplines, and their pedagogy, incorporating research, scholarship and the evaluation of professional practices (Higher Education Academy, 2011).

Findings

Here are at least ten decisions that must be considered by teachers of mathematics. They are grouped by the five Areas of Activity of the UKPSF.

A1: Design and plan learning activities and/or programmes of study

Decision #1: What should students do by hand versus what should they do by calculator, computer, mobile application, or online calculator? For example, does the instructor teach students in a quantitative reasoning course to calculate a savings annuity using the formula or teach them to use an online calculator, focusing on how/what to input and how to read the results and determine if those results are reasonable? A teacher must decide on the comparative value of students working the formulas by hand versus using tools.

Decision #2: Should I incorporate a particular new digital technology into my course design? This depends on a number of factors including whether or not that technology will help learners achieve the expected learning outcomes. There is a certain “cool factor” with some digital technology, but teachers must ensure that any new technology is not a solution looking for a problem. Other factors to consider include cost, accessibility (during and after the course), proven track record, customization, and ease of use.

A2: Teach and/or support learning

Decision #3: What is my role as a teacher and how should technology support or modify that? A teacher needs to consider how comfortable they are in perhaps allowing technology to take some of that role. For example, a flipped classroom, with learners accessing content prior to class, will look very different than a traditional classroom. Can instructors see themselves in a new role or even embrace a new role? The technology, however used, must mesh with the personality, strengths, and flexibility of the teacher.

Decision #4: What is my view of the students’ role and how should technology support or modify that? Some adult students have already been programmed through their school experience to sit and listen and be told how to do mathematical problems. Digital technology can offer a different classroom and learning experience than they may be used to. Technology can offer the student the ability to be more self-directed in their learning and this is often cited as a characteristic of adult learners. But are adult learners able to see their role as different from their school experience?

A3: Assess and give feedback to learners

Decision #5: Is the use of digital technology appropriate for assessing student work and providing feedback? It is easier on teachers to not have to grade homework or answer questions from students or provide feedback. Some software packages can do much of that and also provide analytics on students' work (e.g., item analyses). But, the teacher may not have the same sense as to students' learning needs.

A4: Develop effective learning environments and approaches to student support and guidance

Decision #6: Can I use technology to enhance the students' classroom experience? Of course, this depends on a teacher's teaching philosophy and the purpose of the classroom. Furniture, layout, monitors and display capabilities, smart boards, internet access, and other factors can greatly influence the dynamics between instructor and student, students and other students, and content and students.

Decision #7: To what degree do busy adult students need a physical classroom experience, given that digital technology can provide other ways for connecting with students and content? A teacher can decide to teach online or face-to-face or a combination of the two (hybrid). There are many platforms to choose from in learning management systems, cloud services, social media, etc. Do adult learners need more structure or less?

Decision #8: How accessible is any planned new technology and what can I require of my students? When considering using a particular technology a teacher needs to be concerned with the accessibility of the technology, especially if the students must provide a particular device such as a tablet, laptop, or smartphone. There is still a digital divide despite the proliferation of such devices, particularly with regard to older adult students.

A5: Engage in continuing professional development in subjects/disciplines, and their pedagogy, incorporating research, scholarship and the evaluation of professional practices

Decision #9: Am I comfortable in pursuing and using new technology for my teaching? A teacher wanting to do what will work best for student learning must do some self-reflection on how flexible they are. How willing is an instructor to try something new, despite the learning curve?

Decision #10: Can I take advantage of digital technology to improve my professional development opportunities? Opportunities exist to collaborate with colleagues around the world, if an instructor so chooses. Examples include (a) higher education research

groups like ResearchGate or Scholar's Open Archive; (b) professional organizations such as ALM; or (c) use of informal cloud sharing services or social media.

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Exploring pre-service teachers' attitudes towards statistics: preliminary results

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In the modern era data and information overwhelm every aspect of our lives. Statistical literacy seems the only way for the effective translation of all these data and information. In this framework we conducted a research in a department of education in a university in Greece. The main goal of our study was to examine students' attitudes towards statistics before their enrollment in an introductory statistics course. Data analysis does not show a statistically significant difference between students' attitudes toward statistics as a general field by gender and students' attitudes toward statistics as a course by gender.

Introduction

It is an undeniable fact that we live in a digital era, with great consequences for our personal and social life, our working and learning habits (Artigue, 2013). In this digital era, the social media and the plethora of data are shaping our opinion through the easy access to information (Engel, 2017). According to Evans (2017), in most countries with a developed civil society statistics resembles a kind of axiom on which citizens and policy makers rely in order to take decisions or to form the public opinion. Under these circumstances statistical literacy for all the adults seems to be necessary for the fully understanding of the data and the relevant information since as a notion it is connected with the understanding of data representations and statistical arguments of others.

Although there is not unanimity about the definition of statistical literacy (Sharma, 2017) there is an overall agreement about its importance (Garfield & Ben-Zvi, 2009) and its dimension as the final goal of statistics education. Even if students do not have to perform a research with statistical data, being able to understand statistics could be assistance for them in order to assess the quality of other studies and the validity of their findings

(Sharma, 2017). However, according to Gal and Ginsburg (1994) it is generally recognized that many students begin statistics courses with negative views or later develop negative feelings about the field of statistics. In addition, students who finish their statistics courses with negative attitudes it is not likely to use in their professional and personal lives or in any educational activity the statistical knowledge they had acquired (Shau & Emmioglou, 2012).

The research results about students' attitudes towards statistics at the undergraduate university level, relate their poor performance with their negative attitudes (e.g. Wise, 1985). Most students, especially in humanities' departments take either only one introductory statistics course or generally few pertinent courses. This one course or these few courses seem to be the only way to change the negative attitudes towards statistics of these students.

The main goal of our study was to examine students' attitudes before their enrollment in an introductory statistics course in a department of education. Particularly, we explored:

- students' attitudes toward statistics as a general field and its impact for their lives
- students' attitudes toward statistics as a course they have to complete as a requirement for their studies.

Our research questions were formed as follows:

- Is a statistically significant difference in students' attitudes toward statistics as a general field relative to gender?
- Is a statistically significant difference in students' attitudes toward statistics as a course relative to gender?

Method

For our study's purpose we constructed a questionnaire with 40 questions adapted from the Attitude toward Statistics scale (Wise, 1985) and the SCAS Instrument (Gal, Ginsburg & Schau, 1997). These 40 items measured on a 1 to 5-point rating scale anchored by Strongly Agree and Strongly Disagree. The questions are divided into two subscales, based on factor analytic results (Wise, 1985). Course is designed to measure students' attitudes toward the course in which they are going to be enrolled. The other is attitudes toward the field of statistics which measures students' attitudes toward the use of statistics in their lives as future teachers or more general as citizens.

The participants were 138 students who participated in convenient sampling (81% female and 19% male) in a teacher education department in Greece.

The sampling was convenient and the questionnaire was posted on e-learning platform of the course [<http://survey.ptde.uoi.gr/index.php/579596?lang=el>] with the request to complete it before the start of the winter semester.

Results- Data analysis

The data collected by the questionnaire were analyzed using the Statistical Package for Social Science (SPSS v.25) for Windows. Completed questionnaires were coded and data were loaded to SPSS for statistical analysis. Frequencies (Table 1), means and standard deviations were calculated for all items. A varimax factor analysis was used to reduce the items. Correlation coefficients between the scales were used to determine their relationships with each other.

Table 1: relevant frequencies of the items

	Strongly Disagree (%)	Disagree (%)	Neutral (%)	Agree (%)	Strongly Agree (%)
[I feel that statistics will be useful to me in my profession]	1.4	4.4	24.1	55.5	14.6
[The thought of being enrolled in a statistics course makes me nervous.]**	10.9	38.4	24.6	17.4	8.7
[A good researcher must have training in statistics.]**	1.5	5.8	7.3	46.0	39.4
[Statistics seems very mysterious to me.]**	9.4	34.1	33.3	18.1	5.1
[Most people would benefit from taking a statistics course.]**	1.4	5.1	17.4	58.0	18.1
[I have difficulty seeing how statistics relates to my field of study.]**	19.6	39.9	27.5	10.9	2.2
[I see being enrolled in a statistics course as a very unpleasant experience.]**	13.0	41.3	29.7	10.9	5.1
[I would like to continue my statistical training in an advanced course.]**	14.0	27.9	31.6	22.8	3.7
[Statistics is not really very useful because it tells us what we already know anyway.]**	0.7	2.9	16.9	61.8	17.6
[Statistics is relevant to my performance in my field of study.]**	26.1	56.5	13.8	3.6	0.0
[I wish that I could have avoided taking my statistics course.]**	4.4	22.1	38.2	27.9	7.4
[Statistics is not a worthwhile part of my professional training.]**	13.3	43.7	22.2	13.3	7.4
[Statistics is too math oriented to be of much use to me in the future.]**	26.1	57.2	12.3	2.9	1.4
[I get upset at the thought of giving exams for a statistics course.]**	30.4	54.3	10.9	2.9	1.4
[Statistical analysis is best left to the "experts"]**	8.0	19.6	21.7	31.9	18.8
[Statistics is an inseparable aspect of scientific research.]**	5.2	36.3	33.3	20.0	5.2
[I feel intimidated when I have to deal with mathematical formulas.]**	0.7	0.7	18.4	50.0	30.1
[I am excited at the prospect of actually using statistics for my studies or for my future job.]**	17.6	26.5	20.6	25.0	10.3
[Studying statistics is a waste of time.]**	5.3	23.3	31.6	32.3	7.5
[My statistical training will help me better understand the research being done in my field of study.]**	19.4	59.0	14.9	3.7	3.0
[One becomes a more effective "consumer" of research findings if one has some training in statistics.]**	1.5	8.1	22.8	53.7	14.0
[Training in statistics makes for a more well-rounded professional experience.]**	0.7	9.6	33.1	44.1	12.5
[Statistical thinking can play a useful role in everyday my life.]**	2.9	11.7	33.6	40.9	10.9
[Dealing with large numbers makes me uneasy.]**	11.6	23.9	23.2	32.6	8.7
[I believe that statistics should be required early in one's professional training.]**	4.4	16.1	33.6	41.6	4.4
[Statistics is too complicated for me to use effectively.]**	5.1	33.1	30.9	24.3	6.6
[Statistical training is not really useful for most professionals.]**	6.6	62.0	24.1	6.6	0.7
[Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write.]**	4.4	25.0	39.0	27.9	3.7
[I often use statistical information in forming my opinions or making decisions.]**	11.3	28.6	26.3	29.3	4.5
[To be an intelligent consumer, it is necessary to know something about statistics.]**	5.2	17.9	27.6	41.8	7.5
[Because it is easy to lie with statistics, I don't trust them at all.]**	1.5	18.8	58.6	17.3	3.8
[Understanding probability and statistics is becoming increasingly important in our society, and may become as essential as being able to add and subtract.]**	3.0	21.8	34.6	38.3	2.3
[Given the chance, I would like to learn more about probability and statistics.]**	3.7	11.1	23.7	47.4	14.1
[You must be good at mathematics to understand statistics.]**	3.0	24.4	27.4	35.6	9.6
[When someone bays a thing is preferable to ask an expert than to consulting an owner satisfaction survey in a consumer magazine.]**	0.0	22.4	45.5	27.6	4.5
[I can understand almost all of the statistical terms that I encounter in newspapers or on television.]**	5.3	30.8	32.3	28.6	3.0
[I could easily explain how an opinion poll works.]**	2.2	21.6	35.8	36.6	3.7
[In the future all citizens should be statistically literate]** (adapted)	3.0	20.9	32.8	39.6	3.7
[Statistics is in fact mathematics and it shouldn't be taught as a separate lesson]**	7.4	47.1	29.4	13.2	2.9

* Wise, 1985

** Gal, Ginsburg & Schau, 1997

Factor analysis and reliability

An exploratory factor analysis was first conducted on 40 items. The Kaiser–Meyer–Olkin Measure (KMO) of Sampling Adequacy was 0.889 for the exploratory factor analysis. Kaiser (1974) characterizes KMO measures in the 0.80s as good (Field 2107). Bartlett’s test was significant (chi square = 2557.54, $p < .001$). The results therefore indicated that the sample was appropriate for EFA analysis with Varimax Rotation Method.

The results of the factor analysis confirmed the two-factor instrument with 35 items. All items have a loading of at least 0.30 on their priori scale and on no other scale. Five items either did not load at a value higher than 0.30 on any of the seven factors or did not form a logically coherent group, are considered redundant and removed.

The internal consistency of the items on the instrument was assessed using the Cronbach's Alpha coefficient. Cronbach’s alpha is a measure of internal consistency based on item covariance (Field, 2017; Howitt and Cramer, 2017) and provides evidence that was used to support the instrument’s construct validation.

Reliability coefficients also were calculated for each of the scales identified through the factor analysis. Using the individual as the unit of analysis (Table 2), scale reliability estimates ranged from 0.88 for the scale of attitudes toward field (ATF), to 0.95 for the scale of attitudes toward course (ATC) (Table 3). Thus, each scale shows an acceptable degree of internal consistency (Howitt and Cramer 2017).

Table 2. Descriptive information of each scale.

Sample item	
ATF	Statistics is too math oriented to be of much use to me in the future
	Statistics is an inseparable aspect of scientific research
	Studying statistics is a waste of time.
	Statistical thinking will one day be as necessary for efficient citizenship as the ability to read and write
ATC	The thought of being enrolled in a statistics course makes me nervous
	Statistics seems very mysterious to me
	Statistics is too complicated for me to use effectively
	My statistical training will help me better understand the research being done in my field of study
	I have difficulty seeing how statistics relates to my field of study

Gender differences

The means and standard deviations for the two factors according to gender are presented in Table 3 & Table 4. The t-test with independent samples was used in this study to determine whether there was a significant difference between the perceptions of male and female students. A significant interaction was not observed between gender and the two factors

Table 3: Independent T-Test Gender by ATF

	Gender	N	Mean	Std.	Std. Error Mean
				Deviation	
ATC	Male	21	96,10	22,21	4,85
	Female	91	103,47	15,43	1,62

$t(24) = -1.444$, n.s.

Table 5: Independent T-Test Gender by ATC

	Gender	N	Mean	Std.	Std. Error Mean
				Deviation	
ATC	Male	26	19,65	4,60	0,90
	Female	108	18,08	5,78	0,56

$t(132) = 1.289$, n.s.

Conclusions

Data analysis does not show a statistically significant difference between students' attitudes toward statistics as a general field by gender and students' attitudes toward statistics as a course by gender. Based on the research limitations (especially for the sample selection method), we propose similar research projects to representative samples in national populations and comparative research into similar educational systems. The positive attitude to the field of statistics and courses in statistics must be the pursuit of all educational systems if we want to optimally face the prospect of participation and democracy in a changing world.

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The ‘Transformative Learning through Aesthetic Experience’ method as a way to change adult students’ attitudes towards mathematics

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We present a teaching intervention based on the method ‘Transformative Learning through Aesthetic Experience’ which aims to the transformation of participants’ stereotypes. Thus, our main goal was to alter, at least to some extent, the negative feelings of the adult students towards mathematics. The results suggest a small change in the way that the participants perceive mathematics and to their emotions.

Key words: maths anxiety, transformative learning, basic adults’ education

Introduction

We live in a digital era where images prevail through social media in every aspect of our lives. Digital information and data overwhelm our daily routine making many aspects of traditional mathematics teaching and learning practices look obsolete. This situation in accordance with the mathematics anxiety which constitutes a powerful influence in the process of adults’ learning of mathematics (Evans, 2000) creates a need to incorporate new teaching methods in the class of mathematics for adults. According to Klinger (2011), there is a challenge for teachers in adult mathematics education to find effective ways to diminish the barriers of anxiety and disaffection of their students in order to make them capable to experience success in their mathematics learning, often for the first time in their lives. One of the main institutions for adults’ basic education in Greece is Second Chance School (SCS) which is an experimental EU programme with the educational goal to reduce the social exclusion of adult dropouts who have not completed their compulsory education.

The teaching environment of SCSs is suitable for different teaching practices since there are not any prearranged teaching materials but the curriculum's content of each subject is adaptable and gives the teacher the opportunity to adjust it in accordance with the students' needs and interests. The SCSs students mainly come from socially vulnerable populations (e.g. the unemployed, economic immigrants, prisoners, minorities – especially Romany people and Greek Muslims – the elderly, etc.) (Kollas & Halikia, 2016). Most of these students are adult school dropouts making their return to school a totally different situation compared with their first experience in formal education. According to IDEKE reports (2003), adult dropouts would not prefer to return to a learning environment in which they have not previously been successful, which means that the main features of the education being offered to them need to be remarkably different from those of the formal school system.

Based on the above we tried to incorporate 'Transformative Learning through Aesthetic Experience' method (Kokkos, 2013) in the mathematics class of a SCS in a city in northwestern Greece. Our main objective was to change, at least to some extent, the negative attitudes of the adult students towards mathematics and to present a different teaching method closer to their needs and their everyday reality. Most of these students had expressed their fear of mathematics or their anxiety of failure, a fact that was related to their previous educational experience (e.g. FitzSimons, 1994).

Research on mathematics anxiety is mainly conducted with quantitative methods that incorporate measurement scales like the Mathematics Anxiety Rating Scale (MARS) test or equivalent. These tests are important since they reveal a numerical representation for the level of anxiety felt by the participant but they are limited as far as it concerns the deeper understanding of the origin of such emotions (Ryan & Fitzmaurice, 2017).

Method

According to the 'Transformative Learning through Aesthetic Experience' method the learners are encouraged to reconsider their existing attitudes and assumptions through their contact with works of Art, namely paintings, films or poems. Kokkos (2013) proposed this method in the general framework of transformative learning (Mezirow, 2000), based on the ideas of Dewey, Adorno, Horkheimer and Freire and it refers to the way in which aesthetic experiences reinforce the development of critical dimensions of the learning processes. This method involves six stages (Kokkos, 2013; Kokkos, 2017):

- Determination of the need to critically examine the taken for granted assumptions concerning a certain issue.

- Participants express their ideas about the points of view that need to be examined.
- The educator examines the answers and identifies the sub-issues that should be approached critically.
- The educator identifies several works of art as stimuli for the elaboration of the sub-issues (the works of art are related to the sub-issues). Use of authentic works of art (painting, sculpture, photography, literature, poetry, theatre, cinema etc).
- Consecutive presentation of the artworks. Each artwork is analysed and critically connected to the related sub-issues while the participants express their experiences, feelings and thoughts.
- Critical review and enrichment of the participants' initial opinions. Comparison of the participants' initial opinions with those resulting from the discourse. Synthesis of the results and inferences.

We implemented this method to all three classes of the second cycle of the SCS, in which a total of 50 adult students attended. However, we will present the results of one class, in which we believe that the method was better implemented. Particularly, we designed a teaching intervention during the teaching of geometry notions. There were 21 students in this class, 10 men and 11 women. Their age was from 20 to 65 with a mean equal to 47.38.

Implementation of the method and findings

During our work as mathematics teachers in a SCS we have witnessed, especially in the introductory lessons, the reactions of adult students when they had to confront with mathematics after many years of being away from school. Most of the adult students expressed their fear of mathematics or their anxiety of failure since they brought “a strong affective load of negative preconceptions, both of mathematics and of their own capabilities” (Klinger, 2011, p. 8) which was connected with their previous experience in the mathematics class. We decided to implement the aforementioned method in order to change at least to some extent the participants' negative views about mathematics.

First stage: Participants express their ideas about the points of view that need to be examined (2 teaching hours).

In this stage we tried to record the participants' views regarding the matter of mathematics and how they feel about it. Their views were firstly discussed within smaller groups followed by a plenary discussion session. We asked the participants to discuss in groups for 20 minutes the following question:

- 1) When you hear the word Mathematics what comes to your mind? Is it important in your life? And where;

Then we asked them to write down their answers and try to create a small text that would answer the above question. The participants created three teams with 6-7 members each and wrote the texts below. What is common in these texts is the fear that the participants felt when they returned to the educational system and their belief that mathematics is important for their lives as it enables them to operate successfully every day.

Group A: When we hear the word Mathematics, what come to our mind are problems, additions, numbers, divisions, numerical operations and knowledge in general. But we also feel a difficulty and anxiety. Mathematics is important for our lives and for our everyday reality. More specifically, Mathematics is important for our work, for shopping, for purchases and for sales, for financial matters and for our households. When you know how to handle your finances at your household and your family it is very important. I feel fear that I will not succeed again. Sometimes I feel satisfaction and that I can manage it. Mathematics is important for daily transactions. I would like to avoid Mathematics.

Group B: When we hear the word Mathematics it comes to our mind the operations and the calculations. Mathematics is a wealth of knowledge. But we feel both anxiety and discomfort because in the primary school we were beaten. When we heard that we would do mathematics in the SCS, we thought that maybe we could manage it. Mathematics was the reason for some of us that we did not continue our studies to the middle school. In our lives mathematics is important for our transactions, our finances and our household.

Group 3: When we hear the word Mathematics the first thing that comes to our mind is that it is something difficult and complex. And this makes us nervous. The operations, the numbers, the rules.... It needs thinking and logic. But Mathematics is useful to us in our daily lives, in family planning, in shopping, but also for our work. When we construct a building, we need geometry, we need to count ... If we do not know mathematics we have many difficulties.

Second stage: The educator examines the answers and identifies the sub-issues that should be approached critically.

By reading the texts we identified three sub-issues to approach critically. These were the mathematics' value and usefulness, mathematics and its understanding in relation with the emotions and the role of the teacher in the learning of mathematics.

Third stage: The presentation of artworks and their analysis with the participants (2 teaching hours).

We chose three works of art which assisted in the study and the designation of the aforementioned sub-issues. Specifically, we chose two paintings and a prose piece. Paul Klee was the painter and we chose these paintings because they included shapes and vivid colors.



Figure 1: Castle and Sun (Paul Klee, 1928, Private collection)



Figure 2: Boats at Rest (Paul Klee, 1927, National Museum of Fine Arts, Argentina)

The poet Odysseus Elytis (Nobel prize in Literature, 1979) wrote the prose piece and we chose it because it referred to mathematical notions and to the omnipresence of mathematics.

Entering the twentieth century, in its last quarter, I feel homeless and odd ... People have been relieved of any education... College students solve amazing equations with an ease which makes me wonder: plus, minus, divided by, multiplied by, so. It seems the secret in this life is not whether you are a slave or not. It is to lead yourself consistently to some "so" and to be ready with an answer. So, perhaps a different "so" may be needed resulting from some other systems and mathematics proved in a different way.

Perhaps, it is necessary to teach our children the mathematics leading to the "technology" along with some "lyrical mathematics" leading to the "so" of sensitivity which doubles your ability to perceive life and constitutes an access to the real sense of freedom. Because - to say that too - freedom is not to move unimpeded in the field that has been given to you. It is to investigate this field, especially in terms of the proportion of senses (Elytis, 1992).

The students chose the second painting (Boats at Rest) and for its analysis we used the stages of art observation (Perkins, 1994). We asked the participants certain questions and

we wrote the answers in the blackboard in order to be visible during the teaching intervention.

Part 1: Time for observation

What do you see?

Most students answered: a boat, the moon, the sea, a lot of triangles, a sunset in the sea.

What did motivate your interest?

They answered: the colours, the shapes, the lines.

What do you ask yourself?

What the painter thought when he made this painting? What about his feelings? Did the painter like the Mathematics?

Part 2: Broad observation

Is there anything you would like to discuss more about? Are there any strange things in this painting?

The colours' combination is strange. This painting is connected with geometry. The painter drew the wrong shapes.

Are there any symbolisms?

I see a cross and a windmill.

What do you feel when you look at this painting?

The combination of geometry with the vivid colours makes the painting attractive. Joy. Loneliness, there is not a person in this painting, only shapes and vivid colors.

Part 3: Detailed and in-depth observation

What else makes you impressed?

There are a lot of shapes, a half cycle, different types of triangles, rectangles and squares.

What elements give intensity to this painting?

Intensity is in the red colour of the moon, the white and the black.

Part 4: Composition / Conclusions

Renounce on the project and reconsider it as a whole. Based on what you already noticed try to answer the next questions.

What do you think is its message, what does the painter want to tell us?

In our lives we should use a lot of colours and shapes. The shapes create a perfect image.

Life resembles a boat in the open sea. It has stormy days and calm days. The soul of the man is located in the colors. Through the geometrical shapes we can construct anything we want.

Then we gave the prose piece to every group and we asked the students to read it and to find the words that refer to mathematical notions. All the students found the words. We asked them which person they believe that wrote this text. Some of their answers were: an old man who thinks that nobody wants him (the odd), a person uneducated or a tired person. The students wondered about the expression "*lyrical mathematics*" and in their

answers they tried to connect mathematics with the feelings and sensitivity. When we asked them about the phrase "*proportion of senses*" they said that it refers to the ability to calculate. When we asked the students about the feelings this text created to them, they said that they felt sadness mingled with hope since in the life like in the mathematics there are positive and negative situations.

Fourth stage: Critical review and enrichment of the participants' initial opinions (2 teaching hours). In this stage we compared the participants' initial opinions (second stage) with those resulting from the discourse. We asked the participants to discuss and answer again the initial questions:

- 2) When you hear the word Mathematics what comes to your mind? Is it important in your life?

For 20 minutes every group tried to write a small text and to present it in the class. During the presentation the participants discussed their answers.

Group A: Mathematics is: numbers, deductions, multiplications, additions, divisions, fractions. It is a puzzler... a way to work the mind, the alarm-clock of our mind. It's a pathway, a way to go somewhere further. But mathematics needs study and thought. When we understand mathematics we think that is something easy. Mathematics is like life. Sometimes it is difficult but sometimes looks easy. And Mathematics is important for our lives. It helps us because we open our minds and we learn that there is nothing without a solution and everything is achieved with effort. When we were kids we were scared at the idea of mathematics because it seemed difficult to us. Now, as adults, and with the help of our teacher, we understand it perhaps because we are not afraid of it like when we were young. It is very important in our lives because we meet Mathematics and we need it daily.... I feel more comfortable with mathematics here. I'm not afraid and I learn more mathematics every day.

Group B: Mathematics is a chain when you start it properly... It resembles our lives. It is important for what we need in everyday life, even for the professional life and the future. Mathematics is the A to Z. The way we solve a problem looks like the way we live our lives. And the life problems need mathematics in order to be solved. Mathematics is scaring as far as it concerns the exercises, and the problems. If you get it positively that you can do it, then you can solve the problems of your life. With mathematics you can put your life in order. You can use addition or subtraction... All our life is a mathematical game. From the moment we are born, we begin the mathematical alphabet of our life. We calculate our age and everything else related to our lives. It is important for our lives because mathematics wakes up our mind. They are useful in our daily lives, in our work. It's part of our lives. They help us to do business and not to be deceived. If we know mathematics nobody can deceive us. Let's convey this to our children.

Group 3: Mathematics for me is very important. It resembles life with its difficulties. You have to do things simple to enjoy it. Moreover, colours and numbers are of great value. There are triangles, imagination and puzzles. Mathematics is our very life simply mathematics. As we put numbers in order, we put the priorities in our lives. Without mathematics there are no solutions to any problems

in our lives. Mathematics is like life with abstractions, additions, and many shapes like triangles or rectangles. In every new acquaintance at the end you have to put an equal or a minus before you calculate the final operation in order to find the result. When I saw for the first time the mathematics professor I was amazed with her energy and the way she taught us. I thought that now I will make a great effort and finally I will manage to learn.

Taking into consideration the aforementioned critical sub-issues the salient points in these texts are:

- The mathematics' parallelism with life and its importance for an effective living. Although this conclusion was obvious and in the texts of the second stage.
- The comparison between the emotions they had for mathematics (fear, anxiety) when they were young and now. They say that now they are able to understand mathematics probably because they are not afraid.
- The role of their teacher is highlighted only in the third text and operates as a motivation for learning.

Discussion

We presented a teaching intervention that took place in the class of mathematics in a SCS. We implemented the method 'Transformative Learning through Aesthetic Experience' which is used for the creation of conditions for effective learning through the participants' active participation during the observation of works of art. This method aims to the development of participants' reflective attitude and as a vehicle for the transformation of participants' stereotypes (Kokkos, 2011).

Our main goal was to alter, at least to some extent, the negative feelings of the adult students towards mathematics and to present a different teaching approach. The results suggest a small change in the way that the participants perceive mathematics and to their emotions. At the same time the participants understand the omnipresence of mathematics and perceive it as a tool for the explanation and organizing of everyday life (Beeli-Zimmermann, 2014).

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Development of Questionnaire about Demand of Parents for Mathematical Education to Harmonize family and generation of future era

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The present study is intended to develop questionnaire items among South Korean parents and investigate awareness and requirement for cultural bond and communication between family and generations of the future era in a way of mathematical education.

Introduction

This research aims to develop a questionnaire to investigate the current status and demands of parents for mathematics education to harmonize family and future generations. The field of query has been categorized into two different aspects; the aspect of the state to assess recognition of an object of the query and the aspect to assess the personal variable of each object. To define the field and factors of recognition of the object of the query, recognition of state and phenomenon and satisfaction were separated. In addition, variables of personal background were defined as well for these could operate as additional factor. To secure primary validity, researchers extracted modified fields and factors by the using opinions from internal researchers and professionals in the field of mathematics education. Then, to secure secondary validity of the query and its factors for parents, they performed Delphi questionnaires, consulted with six domestic professionals, and confirmed validity by extracting field and factors of questionnaire for parents. As a result, for the questionnaire for parents with elementary school students, six questions were selected about personal background, seven for mathematical recognition of children and parents, five for teaching activities in the field of mathematics, and seven for general satisfaction concerning the field of mathematics. Additionally, the questionnaire for parents with middle school students, included five questions about personal background, eight for recognition of children and parents about

mathematics, seven for recognition of teaching activities in the field of mathematics, and five for general satisfaction in the field of mathematics. This research has its significance as a foundational study for the mathematics education of the future generation.

Research aims & background

The study aims to develop questionnaire items for South Korean parents to investigate the awareness and requirements for cultural bonds and communication between family and future generations in mathematical education. McDill & Rigsby(1973) report that education aimed at the future society needs to be school education based on life cycle. It is necessary to recognize educational subjects such as teachers, parents and students and explore a way to participate in school education in preparation for the future society. (Tagiuri, 1968; Knowles, 1984). In this context, family math can be cited as a mathematical activity which acts as a tool for creating consensus about a common culture that is shared by family members as math education (Lee, 2012). Our research team aimed to analyze parents' awareness of mathematical activities and requirements to propose family math as a mathematical activity joined by the whole family as parts of math education for parents.

Theoretical foundation

Although parents recognize the importance of mathematics such as AI and big data, they are overwhelmed by ambiguous concerns about methods. Han and Kim(2015) analyzed their awareness of the necessity of software education in elementary schools and obtained favourable outcomes regarding software educational policy and the necessity of software education in elementary schools. They conducted education on various types of software amongst parents and reported efforts for national promotion to include software education into regular elementary school curriculum. Regarding the perception of parents on math learning attitude of their children, Aiken(1974) defined attitude towards math as “personal learned orientation to respond positively or negatively in the situation associated with general mathematical objects or mathematical learning.” Moreover, Fennema & Sherman (1976) classified sub-factors of attitude towards math into success in attitude towards math, parents or teacher's attitude towards math learners, confidence in math learning, anxiety over math, participation motive for math and mathematical usefulness. The OECD definition (2013) included perspectives on math taken by people they considered important, the degree of consent to math class and the degree of consent to math they learn in schools were added in that sections. The implementation of a definitive achievement test OECD(2004, 2013) has a valuable implication in identifying the awareness and feeling of students who are the main

subjects of learning. Questions on parents' attitude towards math are therefore an essential category.

Parents' awareness of learning was found to affect the learning attitude of children (Noh & Kim, 2001). Noh and Kim(2001) reported that elementary school students tend to rely more on parents in terms of studying. Thus, our researchers included successful experience in math, confidence, mathematical usefulness and value perception, anxiety and interest into specific contents in order to understand parents' perception on math. Oh and Hahn (2009) reported that parents tended to be deeply involved in the school curriculum according to their perception of and aspiration towards the curriculum. They also pointed out that middle-class parents who showed strong opposition to the entire current school curriculum, tended to be deeply involved in the curriculum. In addition, the aspirations of teachers who do not separate teaching from caring was similarly found in parents from all classes. Parents of high-attaining children respond to the curriculum rapidly.

Findings

As a study to inform future mathematical education policy in Korea, this study developed questions and analyzed results to explore family union through mathematics. The results showed that parents demonstrated favourable awareness of the usefulness of the math subject and indicated specific methods they would like to see in math classes and parts needed to support math learning in the future. Educational experts should take this into account. Parents' perceptions of the usefulness of math was favourable and value awareness of math was also identified as positive. The following summarise these findings. First, a survey among parents with elementary and middle school students revealed that as more parents participate in education, they become highly satisfied with math learning and activities. Regarding this, it should be said that math education for parents is required in the school level. Second, a math classroom is needed for mathematical activities of the future era in accordance with requests by parents. Third, we propose that family mathematical empathic activities are encouraged since these contribute to creating empathy between generations and cultures.

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Democratic access to digital information

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Official governmental documents in some countries mention democracy, digitalisation, and mathematical competence through education as closely connected terms. Not much is known about how democracy, digitalisation, and mathematical competence through education relate to each other in adult mathematics education in practice? As a starting point, this presentation compares how official governmental documents use the terms in two neighbour countries, which are both Nordic welfare states. The two countries are my own country Denmark and the country of ALM 26 conference Sweden. Secondly, I critically investigate and discuss if and how adult mathematics education practice connect and potentially could connect the mentioned terms. I do this by using sociological theory on equity as access, chance and outcome in order to understand how adults can engage mathematically with digital information in order to participate as citizens in a democratic society. Finally, I exemplify the practical implications for adult mathematics education.

Background

In democratic societies like the Danish and Swedish, adult education serves several aims, one of which is to let participants develop their capability to engage in democratic acts and communication. For instance, the national goals for adult education in Denmark for Preparatory Adult Education² include 'to give adults possibilities to improve and supplement basic skills for strengthening prerequisites for active participation in all parts of societal life'³. The national goals in Denmark for Preparatory Mathematics Adult Education⁴ include 'to increase the participants' possibilities to cope, process and

² In Danish language: Forberedende VoksenUndervisning, FVU

³ Consolidation Act no 602 from 23/05/2019

⁴ In Danish language: Forberedende VoksenUndervisning Matematik, FVU Matematik.

produce math-containing information and materials’⁵ Other educational aims in Denmark are to increase labour market qualifications and capabilities to enter and complete further training and education (Lindenskov, 2018).

At the conference, I will present a comparison between the Danish and the Swedish national goals. The Swedish National Strategy for digitizing education also says ‘Digital competence is basically a democracy issue’. The press message is that ‘Sweden will be the best in the world to take advantage of the potential of digitizing. Education policy has an important role to play in achieving this ambition. The government has therefore developed a national digitization strategy for the school system.’

In my experience, the visionary ideas above are a lot easier to formulate than to implement in practice. It is not quite clear what is the actual meaning of the visionary ideas of capacity to engage in democratic acts and communication, ‘strengthening prerequisites for active participation in all parts of societal life’, and ‘digital competence is basically a democracy issue’. In my view, quantitative as well as qualitative studies are still needed of how adult education can support citizens to critical engage with available digital information, and to answer the question on how we should address equity? (Gutiérrez, 2012,p.18)

Method

First, I develop a theoretical underpinning for investigating citizens’ democratic access to digital information. I am inspired by the discussion of what is equity in mathematics education (Gates & Vistro-Yu, 2003) and by three sociological dimensions of equity: ‘the simple equity of access’, ‘equity of chance’, and ‘equity of outcome’. I present my interpretation of how to use Gates & Vistro-Yu’s ideas of equity in mathematics education to investigate adult learners’ democratic access to digital information. With this background, I analyse some exemplary numerical information in digital media in Denmark and Sweden. I have chosen to use big national television broadcast websites, and to analyse information given at some random chosen dates.

Findings

Sometimes the numerical and geometrical information presented on these websites is distinct, with a clear impact on the narratives being told, but at other times the numerical and geometrical information plays a minor role.

⁵ In Danish language: at overskue, behandle og producere matematikholdige informationer og materialer i hverdagen

At the ALM-conference I will present analyses and findings from April 2019 on the airplane company SAS and on cruise-ships in harbours in Denmark. The numerical information displayed includes 72,000 passengers, 13%, 2.3%, 40%, '4 to 5 working days', 200 mg NO₂ per cubic meter, max 18 days per year, 25-70 meters high.

Practical Applications

In the national curricula in Denmark the idea of 'mathematical awareness' is described. In my view, mathematical awareness – also as a democratic awareness – is in itself important: It is important to notice mathematical information and to consider how the information is meaningful or not for society as well as for individuals. Nevertheless, new mathematics learning materials for adults need to be developed, as well as new teaching methods (Frankenstein, 1983) (Lindenskov, 2014).

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Students and Teachers Learning to Code: Two Worlds, or One?

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The authors have recently integrated computer labs into their first-year courses. At the start of the semester, students showed high levels of anxiety, claiming that they have not done coding in high school. This obviously being a high school to university transitional issue, we designed activities to help high school teachers learn about coding as well. Our hope is that, once they remove their personal barriers, teachers might be better motivated to engage with coding activities in their math classes. Being able to compare, we are interested in possible differences in views, experiences, and actual learning when two populations (first year university students and high school teachers), with no or little prior experience, learn to code in Python? Our preliminary results point to the fact that the two groups show some differences, which will inform how we modify our teaching and learning support for them. However, these differences cannot be confidently attributed to the young-adult divide only.

Introduction

The authors have recently introduced coding activities (“computer labs”) in Python into their first-year courses (calculus for the physical sciences at University of Toronto Mississauga (UTM) and calculus for the life sciences at McMaster University; both universities are located in Southern Ontario). Their reasons for doing so were to offer experiences to students that otherwise would not be there, or not as dominant (Lovric, 2018). For instance, even a simple code could offer creative opportunities for dynamic modelling. Modification of a computer code, for instance by changing the value of a parameter, generates an immediate mathematical reaction (trying to predict what will happen when the value of a parameter is changed is a good learning experience).

Furthermore, coding enhances one’s sense of abstraction, and yet the objects involved have a “tangible feel,” having been created by a user. To code a function, a user needs to

know what the input is (i.e., what kinds of objects the function is going to operate on), what the rule for the transformation is, and what kinds of objects this rule generates as output. Thus, what students often perceive as abstract objects (domain and range, and the rule that defines a function) indeed become “real,” and more “tangible.”

The “low floor, high ceiling” approach that coding promotes invites students with little or no experience to engage; once they learn, they can move beyond the problem they are solving. It takes very little time to learn to code a simple repeating process (loop), and to see the connections between the code and the output (Where does the loop start, and where does it end? How many times does my computer repeat the loop, and what happens with each pass through the loop?). Then, through a sequence of “what if” investigations (What if I change this value? What if I add another line to the loop? What if I insert a loop into a loop?), and with the benefit of the immediate feedback, a beginner learner moves fairly quickly from elementary to more complex coding situations.

We should keep in mind a psychological phenomenon, sometimes referred to as the “fear of new” (as experienced, for instance, by our first-year calculus students when we discuss integration, which is a new topic for many). Upon learning that their course will involve coding labs, a large number of students showed high levels of anxiety, claiming that they will not be able to do it as they have not done any coding in high school (which is indeed true). In our province, the curriculum for *Computer Studies* – whose main component is coding – has been in place since 2008. However, as very few teachers feel (or are) qualified to teach, most schools do not offer classes in coding. Anticipating this, we prepared a gentle introduction to coding, both in written form, and as a video. Asking ourselves what else we could do, we decided to involve high school teachers (adults!), by helping them to learn to code as well. By offering teachers an opportunity to learn about coding, we believe we can remove barriers that they feel are massive and require large amounts of time and energy to surmount. Once this happens, teachers might be better motivated to introduce coding activities in their high school math classes.

Having two distinct populations – undergraduate students fresh out of high school, and high school grade 12 teachers – presented us with an opportunity to contrast their experiences as they learn to code. We focused on the following two questions:

- What are the differences in views, experiences, and learning when two different populations (first year university students and high school teachers), with no or little prior experience in coding, learn to code in Python?
- What kind of professional adjustment is needed to make mathematics teachers more comfortable in a high school coding classroom?

Method

As there is little research on coding in classroom settings (Grover & Pea, 2013; Lye & Koh, 2014), we collected our own data, including: students’ replies to coding activities (including questions about their experiences); teaching evaluations; interviews with a

selected group of students; teacher feedback following the Computing Workshop at UTM in 2018 and 2019; and informal conversations with teachers and high school students. We have barely started to analyze this data, using mixed methods (Creswell, 2014) and the case study approaches.

Of particular interest to us are the “Aha!” moments, or the moments of discovery, when a learner realizes that they “got it,” after what seemed to be a long and unproductive effort. “Aha!” moments have been recognized as important in mathematics because of their “transformative effect on ‘resistant’ students’ affective domains, creating positive beliefs and attitudes about mathematics as well as their abilities to do mathematics” (Liljedahl, 2005). We believe that their importance and benefits naturally transfer to learners of any age who are engaged with computer programming.

Findings

As we are only starting to obtain results, we cannot offer a comprehensive analysis. However, preliminary results point to the fact that the two groups (first-year students and high school teachers) show some differences. Does this mean that adults learn to code in ways that are different from young(er) people’s approaches? It is hard to obtain a definitive answer, and qualify it along some kind of distinction between young and adult. We believe that some differences are correlated to the experiences of learning and working with mathematics (and possibly with other school learning experiences).

We noticed that teachers prefer written instructions (e.g., explanations about what a particular command does embedded into Python code as comments), whereas students prefer watching a video of an instructor explaining steps in coding. (Of course, every generalization of this sort could be easily challenged.)

Most teachers, as well as some students, used pencil and paper to make diagrams and notes as they worked on programming tasks. Working with computer code on screen and working with code on a piece of paper are two different cognitive experiences. In a pencil-and-paper thinking about an algorithm, learners have an opportunity to visualize the structure of a program. For instance, thinking about a nested loop (loop within a loop), they realize that the requirement that the loops must be nested has a useful visual representation - the arcs which join the start of each loop to its end are not supposed to cross! A conditional statement can be visualized as a fork. (Of course, visual imagery can be (and is) realized on a computer as well—some programs use visual interface, which replaces typing the code.)

As well, faced with having to solve a *mathematics* problem using coding, most students start working on screen right away; very few use paper and pencil to try some algebra, draw diagrams, or otherwise reflect on the strategy they will use to approach the problem (Lovric, 2018; Mamolo & Lovric, 2018). Teachers are more reluctant to just type in the code, hit the ‘run’ button and see how it works. Students harvest the benefits of immediate feedback by entering “half-baked code” and seeing what the computer will tell them.

In a task given in a university class, students had to investigate Collatz Conjecture. (This conjecture concerns a sequence of positive numbers defined recursively as follows: start with a number; if it is even divide it by 2, and if it is odd, multiply it by 3 and add 1. For example: 17, 52, 26, 13, 40, 20, 10, 5, 16, 8, 4, 2, 1. Collatz Conjecture states that no matter what number the sequence starts with, it will always end with 1.) The code which students created was able to generate sequences as the one given here - but nothing more than that. An “offline” investigation has a potential of enriching this experience. By “playing” with Collatz Conjecture on a piece of paper a student discovered a pattern: an odd number is always followed by an even number (thus, a sequence of iterations cannot have two or more odd numbers in a row).

To address teaching of coding in high school, we must accept the fact that classroom instruction with a teacher at the front needs a reconstruction. Students cannot be passive observers; instead, they have to be actively engaged in creating the computer code, its testing, interpreting results, and in making adjustments and modifications. Knowledge and skills are gained and improved through *practice*. Teaching coding requires a type of teacher who is comfortable with facilitating experimentation and trial-and-error, encouraging detours, and fostering discovery. In contrast, “Very often, when we teach math, we ‘forget’ how results, theorems, or definitions have been arrived at. We present a proof, but rarely talk about how it was constructed, and in particular, we don’t talk about failed attempts!” (Mamolo & Lovric, 2018)

Another important obstacle to teaching is the content. Our experiences echo the recent report from Sweden: “It is acknowledged that teachers do not often have the content expertise or confidence in teaching ‘new’ topics as they are assigned to curricula” (Hartell, Doyle, and Gumaelius, 2019). A body of research suggests that teachers’ self-efficacy (about a particular topic, or area of mathematics) is positively correlated with their classroom work, for instance in their ability to create effective learning opportunities for their students. Here, we recognize the importance of the “low floor” affordance to coding, which, with early successes, can stimulate teachers to actively engage with coding.

Conclusions

Common to both groups (first-year students and high school teachers) was the initial anxiety of facing something new, which, however, weakened fairly quickly. Although the two groups (might) show some differences in their approaches to coding, we do not believe that they present an obstacle to an effective high school coding classroom instruction. Perhaps the best suggestion to teachers who are considering to teach coding is to be like their students: play, experiment, be creative and explore many directions, and – do not be afraid to hit ‘run’!

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Effective use of digital skills in adult mathematics teaching- a practitioner's view

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I believe by using effective digital skills in the adult mathematics classroom, tutors can deliver teaching based on a more learner' -centred approach, where they can use multidimensional activities and resources based on digital technology: watching topic- based maths videos; maths quizzes; online discussion through Google Stream and so on, which can cater well for spiky profiles (mixed ability groups) to enhance learning and encourage autonomy. As a practitioner and curriculum manager for Mathematics, I will share my findings and analyse both challenges and benefits of using digital skills in and outside the classroom and the overall impact.

Introduction

I work in the ACL (Adult Community Learning) Sector in London, and teach mathematics to adult learners at different levels, according to the National Qualification Framework of the UK: maths level 1 (equivalent to lower secondary school maths in most countries); maths level 2 / GCSE (General Certificate of Secondary Education). After IA (Initial Assessment) learners are placed according to the Adult Numeracy Core Curriculum into three levels: Entry Level, Level 1 and Level 2 /GCSE. Entry Level is further divided into three sub-levels: Entry 1, Entry 2 and Entry 3. Entry level has been set out in this way to describe in detail the small steps required for adults to make progress.

Our learners are diverse in ethnicity, gender, age etc., and some of them have not learnt mathematics in the UK but have studied maths in their country at primary and secondary school level. Most of them learnt maths in a traditional way and they did not have the

experience of learning through digital technology. Therefore, mathematics epistemology in the digital age can be measured through the sources of digital skills methodology and methods used in a classroom.

Method

I believe that, by using effective digital technology such as computer applications, tablets and smartphones, websites and online platforms, tutors can deliver meaningful teaching: moving from dependency (learners relying on tutors) to independence (learning maths independently). They can also create an active learning environment: learners will work independently in and outside the classroom, where they can learn new concepts, discuss mathematical misconceptions with other learners and assess their learning independently. Hence, we can give ownership to the adult maths learners.

Contrary to the traditional maths classroom—dominated by a teacher-centered approach, I will discuss how adult learning takes place in a technology-enabled world of internet networks, websites and mobile devices in and out of the classroom. I will present a practitioner's view on using multidimensional activities; for example, watching topic-based maths videos; maths quizzes; online discussion through Google Stream and other resources based on digital technology, which cater well for spiky profiles (mixed ability groups) to enhance learning and encourage autonomy. Learners receive effective feedback. S Lawrence (201) expressed the same views: "the growing digital tools which are upgraded and updated constantly such as apps and online subscription sites, which give immediate feedback and learning/improvement tools".

Findings/Expected findings

I will report on working with two groups of learners, they are from many different national and ethnic origins. The learners are at the UK level of adult education: functional skills maths level 1 and GCSE in maths. I and the learners will share our experience of using Skillsforward— an e-assessment tool for maths for initial and diagnostic assessments, helping to identify their numeracy level along with the areas for improvement within the adult numeracy curriculum level. We will also express our views about using Mathswatch (online maths videos and interactive questions website) and how it helps to track learners' progress in mathematics. GCSE maths learners will share their experience using Google classroom—a virtual learning platform, helped to remove mathematical misconception by using Google stream.

As a practitioner and curriculum manager for Mathematics at Redbridge Institute of Adult Education, I will share my findings in terms of tracking learners' progress, formative

assessment, and learners' areas for improvement, intervention and exam results. I will analyse both challenges and benefits of using digital skills in and outside the classroom and the overall impact.

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Mathematics epistemology in the digital age

Getting started with OER: a guide to finding, reviewing, and creating

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This presentation is aimed at educators interested in exploring open educational resources (OER) for the adult classroom. For those new to OER, it will introduce and explain the benefits of their use in adult education, and provide resource recommendations and a step by step guide for how to get started. For the experienced OER user, it will discuss insights from our research and efforts curating and testing OER resources. The insights are drawn from the experiences of educators who hail from 21 states and a variety of classroom types—including community colleges, community centers, correctional facilities, and local education agencies.

Introduction

Open Education Resources (OER) have been supported and advocated globally by government agencies for several years. Much of the effort and funding has been at the primary and secondary school level. The research reported in this presentation was funded by the United States Department of Education Office of Career, Technical, and Adult Education (OCTAE). The work conducted during the project explored the rationale for the use of OER in adult mathematics education, identified repositories for suitable material, and supported classroom teachers as they incorporated OER into their unique environment and student populations.

Power in Numbers: Helping Adult Students Learn Mathematics

This project is a response by the United States Department of Education to the nationally recognized problem that math skills significantly affect employability and career options and the fact that many adults lack access to high-quality education and training experiences. It spanned three years, 2016 to 2019, and produced three market scan publications that made a case for the usefulness of OER in adult mathematics education

while encouraging educational technology providers to publish work specific to that audience. The principal investigating body, Luminary Labs, was guided in their research by a team of subject matter experts (SME) of whom the presenter was one. The Luminary Labs staff coordinated the fieldwork that was undertaken to explore and evaluate the practicality of incorporating OER into adult mathematics classrooms.

The Participants

There were nine subject matter experts, some of whom may be familiar to adult educators – Iddo Gal, Jo Boaler, and John Comings – and others who produced educational technology or managed its storage and access and might be less familiar. They met four times for “summits” only one of which was in-person in Washington, DC. The other three were virtual meetings conducted using free teleconference software. That, in itself, represented an application of technology that could be used for instruction. Several of the subject matter experts also conducted month-long discussions with the members of the second group of participants, the classroom teachers.

Two cohorts of educators, 37 in all, accessed OER that they thought appropriate for their courses, incorporated the OER into their instructional materials, and reviewed their particular resource for its content and utility. Over 100 resources were reviewed by the teacher cohorts. The second group, some of whom were also members of the first cohort, worked in teams to produce curriculum guides (lessons plans) that benefitted from the use of an OER.

The Products

In addition to the OER reviews and curriculum guides, three reports have been published by the staff at Luminary Labs summarizing the needs of the adult mathematics education community, the potential for OER, and the case for developing and marketing OER products directed towards the adult mathematics education community. These reside on the Literacy Information and Communication System (LINCS) at lincs.ed.gov/state-resources/federal-initiatives/power-in-numbers. The reports are:

- The Math Gap: Implications for Investing in America’s Workforce
- Multiplying Impact: Five Frameworks for Investment in EdTech for Adult Learners
- From Creation to Adoption: How to Develop and Deploy Successful EdTech
- An additional summary report and videos will be released this summer.

Recommendations for Implementation

This presentation offers a summary of curated American OER collections and suggestions for implementing OER in coursework. Comments from the cohort educators will be shared as well as a brief summary of the work from one project in the state of Georgia. Educators from the cohorts were enthusiastic in their response to the project but shared caveats about issues of quality and applicability as well as time demands for first time users. The LINCS community is broader than this project and additional LINCS resources are cited.

Reflections of the Presenter

Earlier presentations at ALM about *Power in Numbers* raised questions of concern to researchers and practitioners. One is the question of access which is still not universally equitable and referred to in the media as the *digital divide*. A second is the broader question of ownership of educational products. The open access nature of OER diminishes traditional copyright protection and the profit, however small, that results from academic publications. Intimately tied to that question is that of “Who owns materials produced within an educational institution?” The answer varies and the permission to allow open access may be out of the hands of the author.

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Combining Computer Adaptive and Persistence Software for Motivation and Placement of Adult Students in Gateway College Math

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Due in part to a large number of major military bases in the region and partially because of the nature of many Las Vegas work opportunities, the University of Nevada Las Vegas enrolls a significant number of adult learners that are taking advantage of higher education opportunities for the first time. Many of these students do not have a current placement assessment to report and must demonstrate readiness for college in some other fashion. This session examines the particulars and the implications of engagement with the ALEKS Learning and Knowledge Spaces Placement Assessment and computer-adaptive instructional modules to better place and prepare adult learners (N=300) who were deemed “not yet ready for college math coursework.” Data affirmed that 10+ hours of additional study in ALEKS modules had large effects on subsequent placement scores and on problem-solving success and deeper engagement in subsequent Gateway math classes.

Introduction

The Mathematics Learning Center (MLC) at the University of Nevada Las Vegas (UNLV), a R1 university, was established for several related reasons, each connected in some fashion to the importance of addressing the needs of beginning or returning adult students that are engaged in remedial or preparatory mathematics course for “gateway” college credit courses.

The University of Nevada Las Vegas, and other institutions, use the results of a sophisticated, computer-adaptive, diagnostic mathematics placement assessment (ALEKS) to help determine adult student readiness for, and placement into, college level

courses upon acceptance. The unique benefit of using the ALEKS Placement, Preparation, and Learning “package” is that it allows adult students to establish a benchmark and then study personalized prescriptions designed to improve their level of preparedness and likelihood of success in a course. Our research demonstrates that students who spend time mastering topics in an ALEKS Preparation and Learning Module prior to (or during) any course, then perform better in that course. The impact of establishing higher cut scores is to encourage students to make use of an ALEKS Preparation and Learning Module and therefore to achieve better success in whatever mathematics course they must take as a requirement of their chosen degree.

Framework and Study Aims

Assessment and Learning in Knowledge Spaces (ALEKS) is a widely used adaptive math problem solving software designed to provide math instruction to a wide range of learners. Universities use ALEKS placement assessments to determine students’ readiness for college level mathematics. The placement, preparation, and learning (PPL) interface assesses proficiency needed to enroll in credit-bearing university math courses and, for students not yet proficient, provides adapted problem-solving lessons to improve their proficiency prior to future placement attempts. Little is known about how not-yet-proficient learners use ALEKS to prepare for second attempts, and whether they benefit from doing so. If aspiring students can indeed achieve proficiency and eligibility to enroll in credit bearing math through brief restudy, universities can adopt ALEKS PPL to speed credit acquisition, and shorten time to degree. The study focuses on events of 296 aspiring adult college students who earned admission to university, but who had no placement information or whose initial placement score confirmed a lack of proficiency needed for credit bearing math..

Methods

We examined trace data from ALEKS sessions after an initial failed placement assessment attempt and before the second assessment attempt. Students (N = 296) graduated high school, failed their initial placement assessment, spent 10 additional hours solving problems in ALEKS prior to a second assessment attempt. We examined (1) improvement in ALEKS assessment scores after 10 hours of additional study, (2) how traced problem solving events in ALEKS relate to learning outcomes AND (3) whether positive outcomes are associated with elective, self-regulated learning behaviors not prompted by ALEKS: seeking out problem solutions using Explain features and Review mode.

Table 1: Definitions of Variables for the Analysis

Variable Definition	
C vs. W	Correct/Wrong response to the item.
E vs. L	Student looks at an explanation page called by the student / prompted by ALEKS Review. Student elect to access a review mode to any previously mastered.
% Correct	Correct responses divided by total correct + wrong responses to items

Results

We compared placement scores on attempts 1 and 2 using a dependent samples t-test and found a significant and large effect of restudy on assessment scores, $t(295) = 31.224$, $p < .001$, $d = 2.29$. Scores rose 29.7 points ($SD = 16.3$) from 33.1% mastery ($SD = 8.6$) to 62.8% ($SD = 17.3$) and of the 296 who completed 10 hours of study and a second assessment, a significantly greater proportion achieved proficiency (i.e. $> 46\%$ mastery) and gained eligibility to enroll in credit bearing math than did not, $c2(296) = 109.46$, $p < .001$. Having confirmed that scores increased after engagement with ALEKS, we next examined how learning events during that engagement (i.e., Table 1) associated with six learning outcomes: ALEKS placement attempt 2 score, improvement across attempts, Eligibility to enroll in Credit-bearing math (binary), Fall Math course GPA, Semester GPA, and Spring re-enrollment at the university. Bivariate correlations revealed no association between behaviors and second placement score nor credit-bearing math eligibility. Those who earned higher placement scores answered more items correctly during study ($r[296] = .119$, $p = .04$). Those who engaged with more ALEKS-prompted explanations achieve greater gains ($r[296] = .125$, $p = .03$); the relation between gains and learner prompted views of explanations was weaker and not significant, $r(296) = .065$. The act of seeking explanations was, however, significantly associated with performance in math courses once enrolled, $r(211) = .213$, $p = .002$, and may thus confer benefits at university. Additional results indicate more complex relations wherein performance during learning in ALEKS predicts initial Math GPA differentially by course type (credit-bearing vs. developmental).

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Adult numeracy demands of digitised health information

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Advances in communication technologies and medicine mean citizens are increasingly seeking, accessing and interpreting a growing volume of health information through digital means. In this study we seek to understand the impact of adult numeracy on how parents' access and use this information to support their children's healthy development. To do this we survey a cohort of parents/carers (n=155) of primary school aged children) living in a regional city characterised by high levels of social disadvantage. The survey makes use of the validated General Health Numeracy Test and we report on our initial analysis with respect to relationships between measures of health numeracy, the nature of information accessed (print vs. digital) and demographic factors (including SES, health status of associated children, education level, gender, language background and Aboriginality).

Introduction

Advances in communication technologies and medicine mean citizens are increasingly seeking, accessing and interpreting a growing volume of health information through digital means. The processing of this information requires a set of skills referred to as health literacy and health numeracy. This is a relatively new and emergent focus of study: Regarding adult literacy a more substantive and growing base of research exists in the health context whereas adult numeracy research has typically focused, for example, on the workplace context. In this study a principal focus is the impact of adult numeracy on how parents' access and use information that can support their children's healthy

development. In our presentation we consider the adult numeracy demands of digital materials used in this context.

Method

As part of a larger program of research, this study brought together a team of literacy, numeracy and regional health specialists to investigate the health literacy, numeracy and information usage of a cohort of parents (n=155 parents/carers of primary school aged children) living in a regional city characterised by high levels of social disadvantage. Our recruitment strategies enabled us to obtain a participant cohort considered more representative of the local population than parent survey cohorts usually are. This is relevant from the perspective of adult numeracy research, since the target populations for interventions and studies are often people with lower levels of education.

The survey contained 35 questions that combined quantitative and qualitative elicitations to build a detailed profile of participants' health literacy, numeracy and information usage, and the sources used to inform their decision making. With respect to adult literacy, the survey used the validated All Aspects of Health Literacy Scale (AAHLS). This instrument requires participants to respond to 13 statements; eleven 3-4 point frequency Likert scale and two using a dichotomous response format. With respect to adult numeracy, the survey incorporated the 6-item version of the validated General Health Numeracy Test (GHNT), which was designed with the goal of helping "providers and educators tailor [mathematics] education to patients" (see here). This instrument requires participants to respond to five open answer questions and respond to one dichotomous response format question.

In our presentation we will report on our analysis with respect to relationships between measures of health numeracy, the nature of information accessed (print vs. digital) and demographic factors (including SES, health status of associated children, education level, gender, language background and Aboriginality).

Expected findings

We expect to find a complex model of relationships between demographic factors, general literacy/numeracy, health-specific literacy/numeracy, health domains, and health outcomes. We predict that higher levels of education would be associated with higher performance on the GHNT, as well as the use of a greater diversity of sources inclusive of traditional, web-based and human sources. While we have smaller numbers of fathers, we could expect gender patterns regarding numeracy to play out in the GHNT measures. We also expect that performance in the AAHLS would be better than

performance in the GHNT, partly because the AAHLS measures more than just the ability to comprehend information but is inclusive of health communication and critical health literacy.

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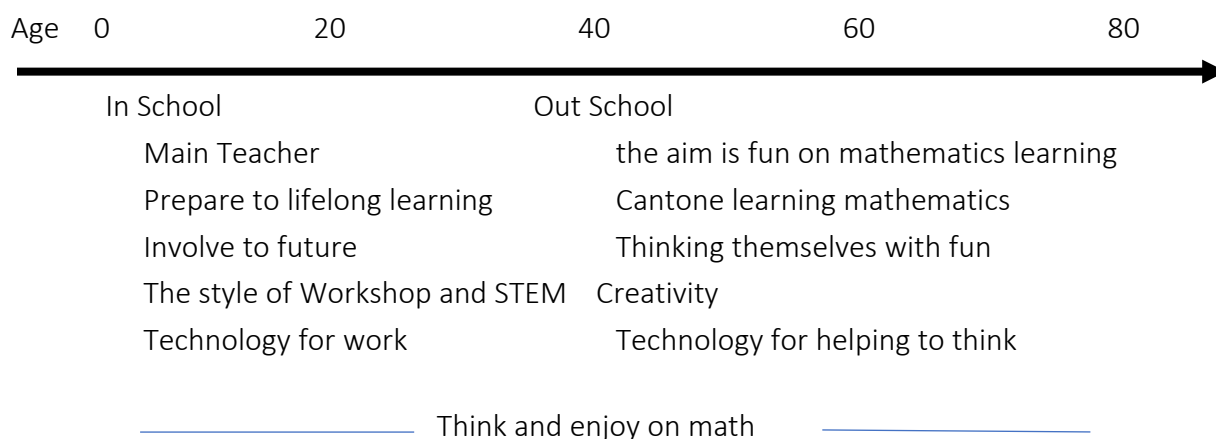
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“Out School” Mathematics Learning

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Play → Inductive → Deductive and Proof → (Create and Inductive) → Play

What is “In School” and “Out School”? A suggestion for lifelong learning of mathematics. We think that lifelong learning of mathematics is saying “Out School” learning. Learning styles, are broadly divided into two, one is “In School” and the other is “Out School”. What is meant by “In School” and “Out School”? “In School” is same as the school education system. In this system there are students and teachers and the lead is given by the teachers. In this style, the teacher is in a position of authority and the student is in a subordinate position; learning mathematics is a top down process in which the students are given the theorem and problems by the teacher. A diagram of “In School” and “Out School” Learning Structures. (Fig.1)

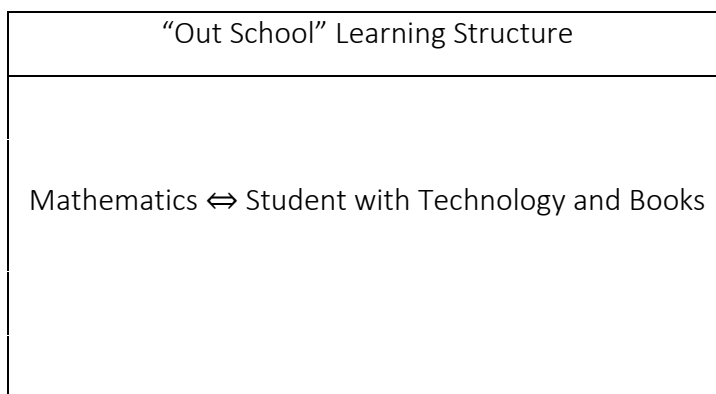
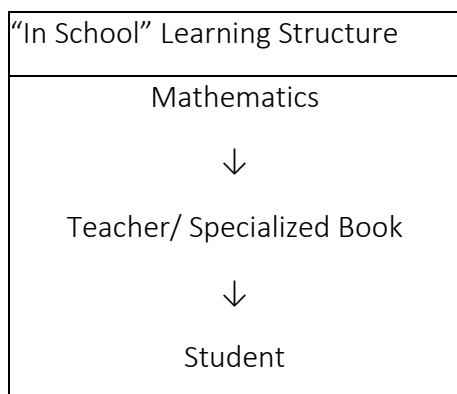


Fig. 1 “In School” and “Out School” Learning Structures

We want to think about lifelong learning as “Out School”. It is said that lifelong learning can be divided into four fields.

- (1) Adult class (back to “In School” learning)
- (2) In-house training (in a business, government service or other organization)
- (3) Preparing for a new profession
- (4) Personal joy/fun

In these fields, we think that (1), (2) and (3) are “In School” education, only (4) is “Out School”. In this field, the aim of mathematics education is to enjoy mathematics learning. So, the next table is the differences between “In School” and “Out School”.

Table 1: Comparison of “In School” and “Out School”

	“In School”	“Out School”
Investment	Education as investment Preparation for occupation Expectation for the future	No investment
Place	School / cram school Vocational training Company training On Line	Home Library / Museum Public place Community center
Method of thinking	Deductive thinking Proof Critical	Inductive thinking Mathematical experiment Creative
Technology	On Line Assistance Help	Assistance for technical skills Not only to get answers but aid to think
Aims	Getting knowledge Be useful math	Personal joy/fun
Motivation	Passive motive Learning is an obligation Right to learn	Proactive motive Active motive Personal joy/fun
Concept	Systematic teaching materials Course of Study Syllabus	Personal Choice (Freedom)
Material	Textbooks / reference books Given teaching materials Exercise books	Books/Informants/Newspapers/Magazines /Radio/Television/Films/Plays Technology Thought Enlightenment Paper/Book
Assessment	Examination / Dissertation Evaluation is given	No evaluation Verification Emphasis on self-evaluation

We think the most important element of mathematics is “to think”. For learners who are taught “In School” mathematics in the past (past learning experience), their next stage of mathematics learning (lifelong learning) will most likely be “Out School” learning. The method of “Out School” mathematics learning is the inductive thinking, whereas “In School” is logical thinking, that is deductive (Fig 2.).

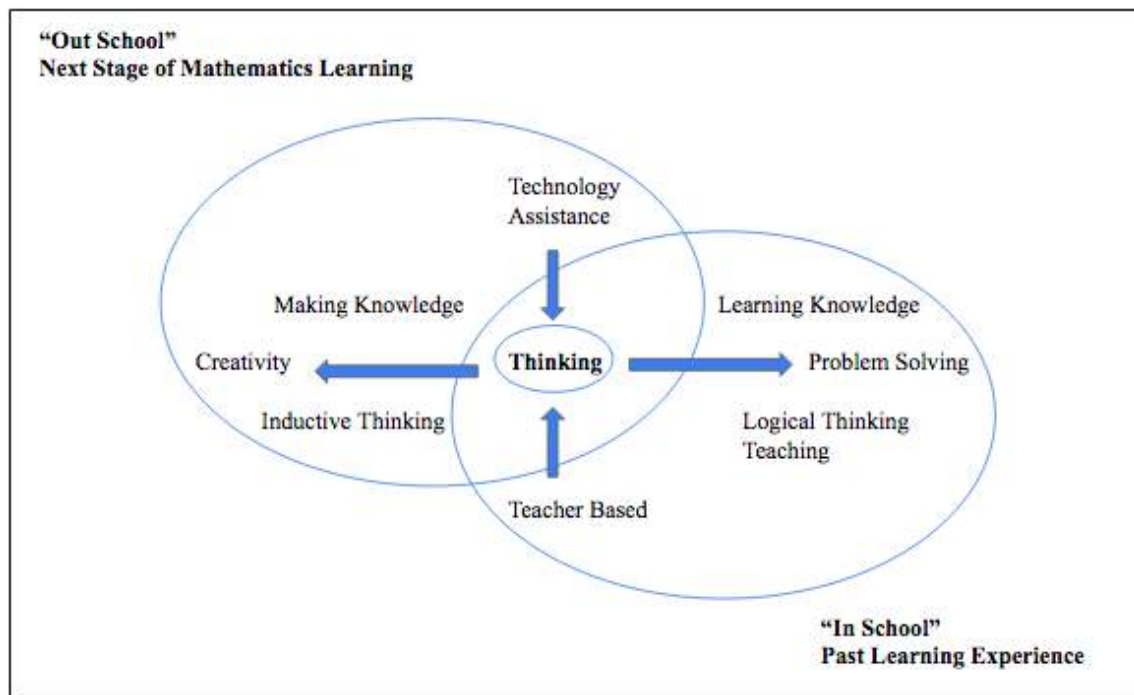


Fig 2. A relation between “In School” and “Out School”

Expected discussion

We introduce an approach to the lifelong learning of mathematics and consider how lifelong learning of mathematics may develop in Japan.

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Using Digital Video to Explore the Details of Student Talk in the Adult Mathematics Classroom

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An established body of evidence suggests a strong relationship between classroom dialogue and student learning. Despite the growing number of studies of young people in this area, productive dialogue in the adult mathematics classroom is less well understood. Use of video as a methodology offers a promising means to understand the development of adult student's mathematical thinking. This paper explores student participation and learning in an adult algebra classroom. Using videotaped whole-class and small-group discussions in one algebra classroom, I analysed how students engaged with each other's mathematical ideas. The results suggest that attending to the details of student participation is central for understanding productive classroom dialogue and how to promote it.

Introduction

The adult algebra class is astir as eighteen students work on a task based on J.A.H. Hunter's poem, A Tale of the Cats. An iPad captures the instructor as she moves from table to table to support student thinking. Six iPods mounted on desktop tripods record pairs of students as they read and re-read the problem, pose questions, add to an idea, challenge a claim, correct a misconception, and reason about a proposed solution for the mystery of the cats on Algebra Street. The digital video cameras in this classroom produce hours of footage that will help identify and describe how productive dialogue can facilitate the development of adult's mathematical thinking.

Although the study of classroom dialogue dates back four decades (e.g. Howe, C., & Abedin, M., 2013), there is an increased focus on dialogic interaction that promotes student learning (Resnick, Asterhan, & Clarke, 2015; Webb et al., 2019). Especially notable has been the extension of research on student participation to adult mathematics classrooms (e.g. Díez-Palomar, J., 2017). This paper builds upon previous research that shows how attending to the mathematical details of student participation, teacher support of student participation, and classroom settings in which conversations take place is central for understanding productive dialogic interaction and how to promote it in the adult education classroom.

Much previous research has described the benefits of student talk. Explanation and engagement with each other's ideas can deepen a student's own, and their peers', understanding. Students enrich their mathematical understanding through multiple means when interacting with a peer: they construct shared meanings, monitor thinking, address misconceptions, reconcile discrepancies, supplement gaps in understanding, acquire new knowledge, and gain confidence and improve perceptions of mathematical competence while doing so (Bargh & Schul, 1980; Boaler & Greeno, 2000; Brown, Campione, Webber, & McGilly, 1992; Chi, 2000; Forman & Cazden, 1985; Gresalfi, 2009). Empirical findings from previous studies also suggest that active student participation is beneficial to student learning (e.g. Chinn, O'Donnell, & Jinks, 2000). Notably, researchers have found relationships between giving explanations and learning outcomes (Ing et al., 2015; Veenman et al., 2005); results that suggest students, guided to elaborate their own ideas, demonstrated greater learning outcomes than students without guidance (Gillies, 2004; Mercer et al., 2004).

Paying attention to the details of classroom interaction matters. I examine the role of digital video in facilitating research to investigate 1) the nature of student participation in dialogic interaction—specifically, explaining one's own thinking and engaging with others' ideas—that is most predictive of student learning outcomes, and 2) the nature of teachers' ongoing interaction with students that supports their engagement with each other and the mathematics.

Methods

The sample included one instructor and her students ($n = 18$) in an adult algebra classroom from a community adult school in a large urban metropolitan area in the United States. The teacher was selected based on her 1) commitment to creating a classroom environment that promotes student participation and 2) her willingness incorporate activities derived from Cognitively Guided Instruction (CGI) to help her attend to the details of students' mathematical thinking (Carpenter, Fennema, Franke, Empson, & Levi, 1999).

I collaborated with the instructor for 14 weeks to modify tasks and support moves to better elicit student's mathematical thinking. For ten observation days during the 2019 spring trimester, I video recorded student-student and student-teacher interaction during the first hour of a 2.5-hour class. Multiple cameras captured all teacher and student interaction in three classroom participation structures: small-group problem solving, whole-class discussion, and turn-and-talk.

In examining student participation, analysis will be based on the application of video coding software to develop and describe profiles of student participation across multiple classroom structures. Coding of student explanations will focus on the level of detail of explanations (fully detailed or partially detailed); coding of student engagement will focus on the extent to which students engaged with each other's ideas (adding onto another's idea or referencing the details of another's idea but not adding on).

Expected Findings

The expected findings will show how attending to mathematical details of student's dialogic interaction and teacher support of student participation are important for understanding classroom interaction and for shaping conclusions about classroom dialogue that is productive for student learning. In addition, coding student participation and teacher practices for each phase of the lesson (whole-class, small group, turn-and-talk) will help to gain a better understanding of the interrelationships between interaction in these contexts.

These outcomes will help instructors of adult education mathematics identify and develop tasks, vary classroom participation structures, and integrate teacher moves that support students to explain their ideas and engage with their peer's ideas. This study aims to not only improve student learning, but to also explore a potential increase in student retention and achievement.

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Workshops

The Red Circle project: How mathematics can be embedded in online gaming quests for enhancing learning and teaching

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'The Red Circle' is a part of a larger project that aims to promote learning through virtual, social and competitive environments by establishing a new gaming genre named EduMMORPG. The name derives from the word 'educational' and the already existing gaming genre of Massively Multiplayer Online Role-Playing Games. This project aims to investigate the quest line and a preliminary skill line of an RPG associated with mathematics. A high fidelity prototype is developed in order to create the base for the mechanics and feel of the game. The prototype is designed as a fantasy RPG with mathematical problems included as key elements of the gameplay. Quick reaction multiple-choice questions are integrated into the combat mechanics and more complex problems are embedded in the questing system. Pedagogic techniques of teaching mathematics are explored in order to provide realistic expectations for the impact of the game in today's education. An experiment where potential users shared their opinions on the current state of the game is further discussed.

'The Red Circle' is a demo game that explores how mathematics can be embedded in online gaming quests for the benefit of the current mathematical teaching practices. The wider project takes place in a PhD degree and aspires to introduce a new approach to learning, using pedagogic techniques of teaching mathematics in an attempt to create a multiplayer game that is worthy of comparison to alternative competitive games in terms of mechanics, balance and entertainment.

A fantasy world which accommodates a story line was built in UNITY environment and the scripts were written in C#. The educational level that it works with is GSCE and can assist adult learners who need to refresh their knowledge or learn mathematics.

Related Studies

As examined by Anagnostopoulou (2016), there are various studies that investigate MMORPGs as a teaching method for schools.

The educational value of MMORPGs, as studied by Wagner (2008), demonstrated that the social aspect of MMORPGs is an important motivational factor that can engage potential students in their learning in an analogy to their learning efforts for the mechanics of a game. Moreover, the strategic thinking and problem solving aspects of the MMORPGs can effectively be used in education.

Steinkuehler (2004) used Lineage MMORPG to study the informal online learning features of its environment and find which are productive and which are not. He examined how cognition can be socially and materially distributed and concluded that players shape their individual identities through interaction with community activities, values, and goals. The elements, components and structures of learning through games were also described by Tang et al. (2007).

Habgood (2007) studied the effective integration of learning content into digital games, through Zombie Division, a maths game for KS2 students. He concluded that intrinsically integrated games are more effective than extrinsically integrated games as they motivate the players to profoundly connect with the learning material. He also argued that the fantasy aspect of RPG games is not the main feature that the players engage with the game; fun is more essential.

Squire and Giovanetto (2008) used Civilization III, a history simulation game to examine the key structures of learning evolution in games and concluded that active participation in a game is fundamental to game-based learning systems.

In another study conducted by Trybus (2014), three systems of learning were compared and contrasted: traditional, practical, and game-based learning. Trybus concluded that game-based learning not only combines all the benefits of the other two systems but it can also be more beneficial and provide a faster learning curve.

Suh, et al. (2010) found significant differences in terms of achievement in English education for elementary students. Susaeta et al. (2010) designed a Classroom Multiplayer Presential Role Playing Game (CMPPRG) for teaching ecology as an afterschool classroom activity.

In ReLIVE 08 conference, hosted by the Open University (2008), researchers discussed multi-user virtual environments (MUVES) in teaching and learning. The Open University purchased Cetlment Island in Second Life, a virtual world environment and examined the potential that this environment could offer for working with their students.

However, the results of these studies have not yet been successfully implemented and the game genre, EduMORPG, proposed within the scope of the current project is still absent from today's gaming industry. Moreover, the current educational system is evolving worldwide, in terms of technology enhanced learning and incorporating games in the teaching and learning practices. Hence, there is a gap in the education industry that an EduMORPG can cover.

Methodology

Aim

The project aimed to explore ways with which an engaging story line of an RPG can be used to provide motivation and assist the learning of mathematics. Specifically, in which parts of the game, mathematics can be embedded without diluting the entertaining aspect.

Method

A high fidelity prototype of a game was developed in UNITY, introducing unique game mechanics and innovative gameplay. The game was set in a medieval setting with a relevant story line, which follows a series of quests to guide each player through their knowledge path (fig. 1).



Figure 1: Questing area (Olivotos, 2019).

The quests were essentially the main learning part. They contained mathematical questions ranging from short to long questions, covering basic algebra, geometry, trigonometry, logic, probability and statistics.

Mathematics was embedded in the quest line in the following ways:

Medium questions were asked by NPCs (Non-Player Characters) who interacted with the player through a dialogue box, giving directions for the quest (fig. 2).

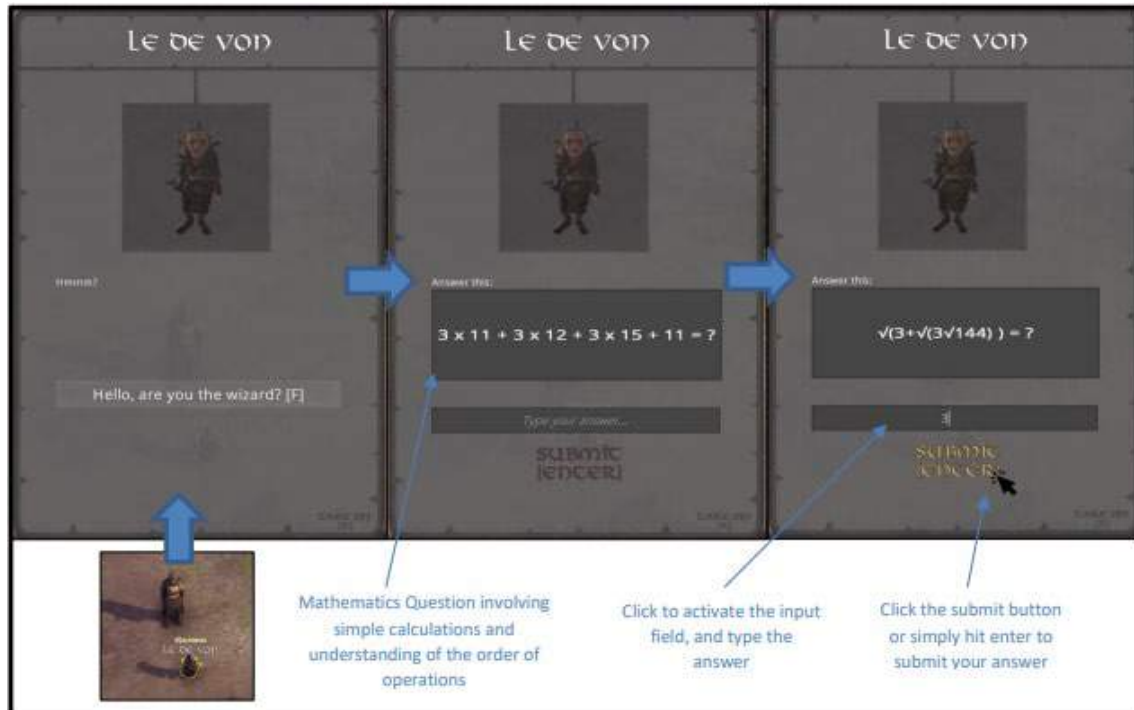


Figure 2: Medium questions by NPCs (Olivotos, 2019).

Interactive items, like chests to be unlocked, contained long questions (fig.3). The player had to find the correct answers which comprised the combination of the lock. For each correct answer the central 'L' shaped bar was rotated to fit in the 'L' shaped hole in order to open the chest.

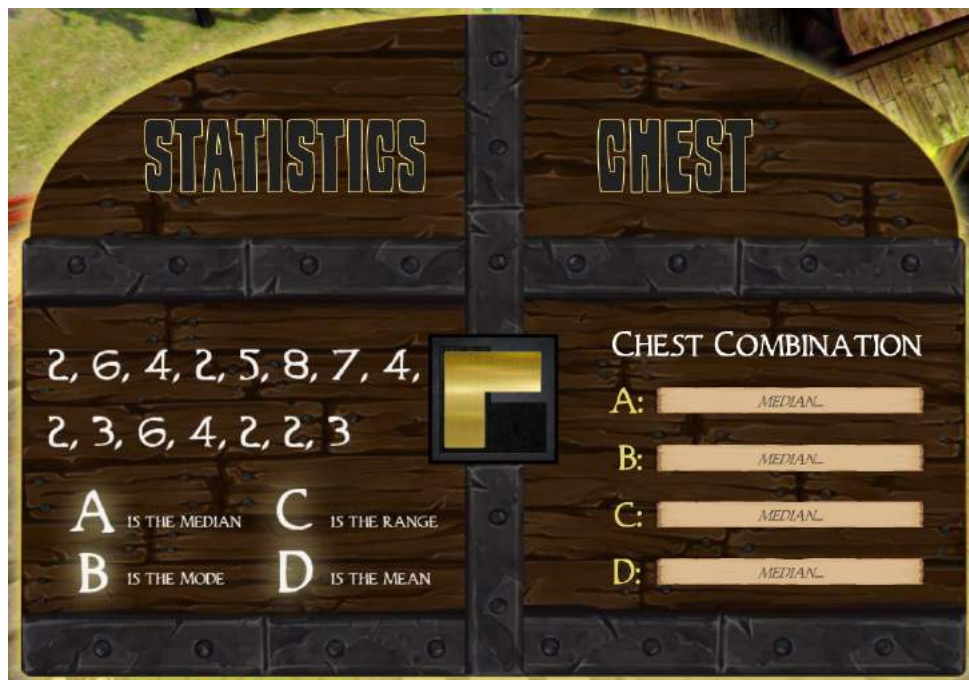


Figure 3: Long questions that unlock chests.

The quest line also contained logic questions like the one shown in fig.4. The player had to explore the map and interact with more than one NPC to get the right answer.

1. There is exactly 1 false statement in this list.
2. There are exactly 2 false statements in this list.
3. There are exactly 3 false statements in this list.

Exactly how many false statements are there in the list above?

Figure 4: Logic question that require map exploration (brilliant.org, 2019).

Short multiple choice questions were introduced with the activation of certain abilities (skills) of the player. A resource called 'energy' (blue bar in fig. 5) was dissipated when the player used their abilities. Each skill required an amount of energy to be casted. When the blue energy bar emptied, no skill could be casted and recharging was needed. By pressing 'S' in the keyboard the skill bar was changed to a wheel with short and quick multiple choice questions with 3 possible answers, as shown at the bottom picture of fig. 5. For each correct answer a part of 'energy' was regained. To prevent players from guessing, there was a short stun effect as a penalty for choosing the wrong answer.

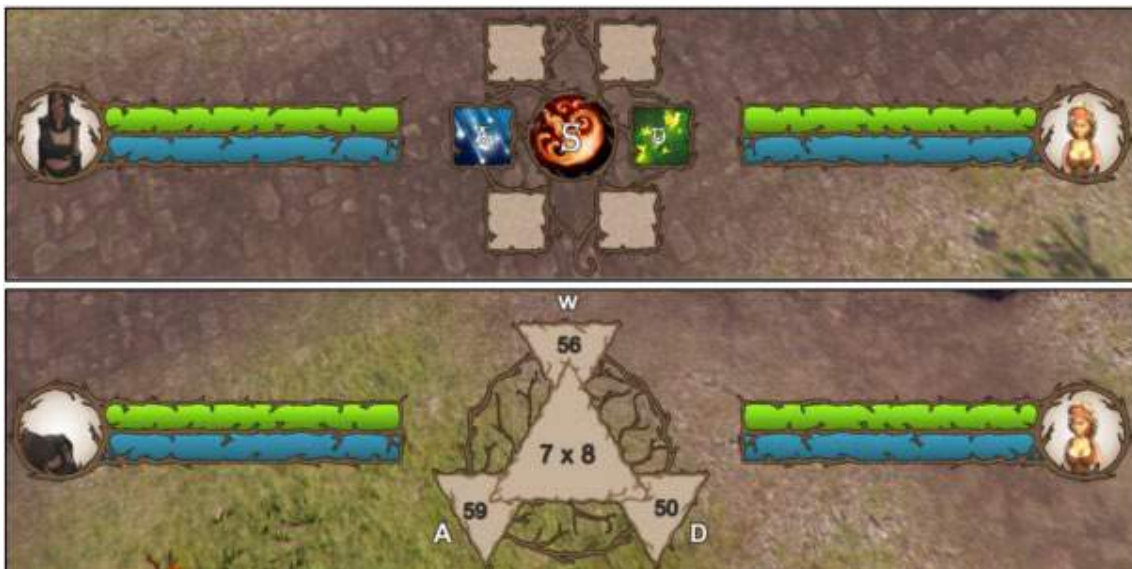


Figure 5: Short multiple choice questions in the combat wheel.

Interactive 'billboards' were set on the scene, where the player could find the relevant information to solve mathematical questions, if needed.

Data

Data was collected in two phases.

Phase 1: As an initial testing phase of the game, which would inform for any improvements or hot fixes, a short experiment was conducted involving 8 participants and fifteen minute session of gameplay. The participants had considerable knowledge in both gaming and mathematics and were asked to score, from 0 to 10, four focused areas: effectiveness of user interface and hotkeys, extent of intuitiveness, quality of entertainment and degree of integration of mathematics in game mechanics.

Phase 2: The participants were asked to play the game and complete the quest line. The gameplay duration varied from 30 to 50 minutes, depending on how experienced the players were. The participants were adults, with age range of 20 to 70 years old. The sample was selected to be comprised by both gamers and having no game experience, and having mathematical prior knowledge and little maths skills.

Upon completion of the game, the participants were asked to complete a questionnaire. Data from the questionnaire was collected and analysed.

Data collected was anticipated to answer the following questions:

- How engaging was the game? Which parts did the players find more enjoyable? Would the players play this game again? Would they recommend it to a friend?
- Was the quest line clear? Did the players know what they were asked to do? Were the players able to find information in game to complete the quests?
- How difficult was it to navigate and use the UI?
- How much did the maths questions distract their entertaining experience?

Results

The results of *Phase 1*, shown in fig.6, provided a general positive feedback with “quality of entertainment” to be rated higher. Open questions feedback informed and advised on modifications that would improve the game intuitiveness and the integration of mathematics in the mechanics. A new improved version was then built implementing suggested changes; for example, the map feature was improved to show the location of player and the location of the next quest.

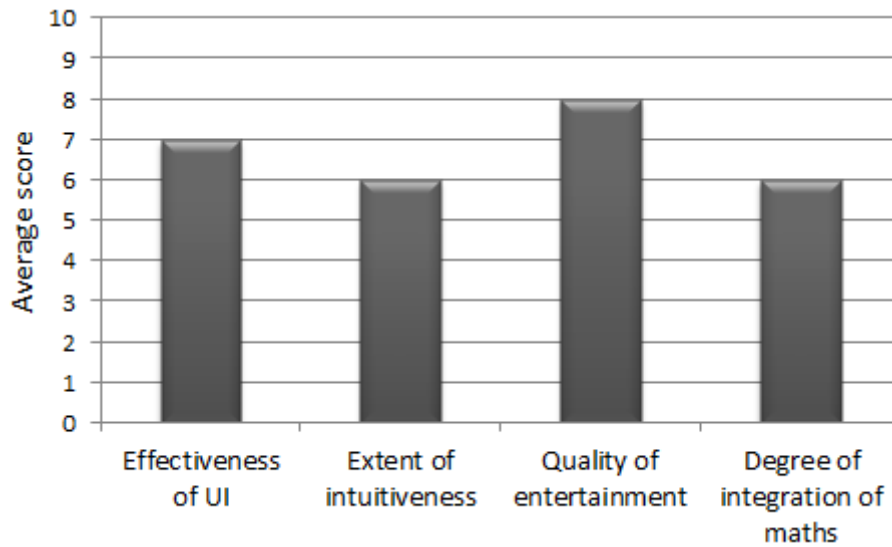


Figure 6: Average score of each focused area (Olivotos, 2019).

In *Phase 2*, the participants tested the upgraded version and were asked to rank their preference for the following game features: maths content, story line, quest sequence, landscape and virtual environment, non-player characters personality, graphics (movement, skill casting, dialogue boxes, etc.), combat and fighting techniques.

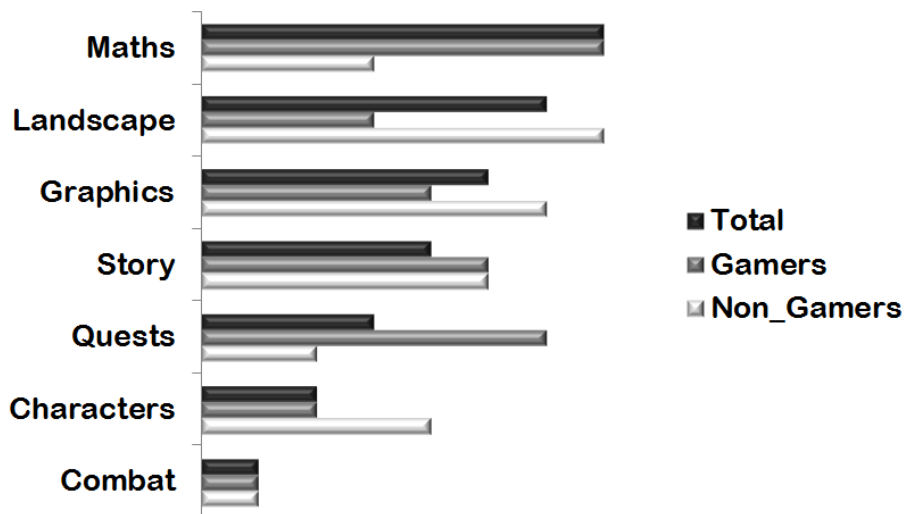


Figure 7: How gamers and non-gamers rank the game features

Fig. 7 ranked the maths content as first, with gamers stating that it is their first preference. Non-gamers picked landscape as their first choice and graphics as their second which verifies that a well-designed virtual environment is engaging and motivates to carry on playing a game (Wagner, 2008).

An interesting result is that the 'combat' feature was ranked last by both gamers and non-gamers. Data from the open questions in the questionnaire revealed that the players

found the use the multiple choice wheel too fiddly. They would prefer to have to type the answer rather than choose the correct letter. Gamers also commented that they found the wheel distracting while in combat. Hence, the skill wheel is to be reviewed at a future version of the game.

Comparing feedback between gamers and non-gamers, in terms of the aspects presented in fig. 8, the results showed that both categories found the game innovative and worth of recommendation. The quest line was clear to follow and all could easily navigate through the map irrespective on whether they have any prior game experience. A worthy comment here has to do with the dialogue content during questing. Non-gamers found that there was a good amount of dialogue, whereas gamers thought that it was a bit much. Through observation while playing, they were noted to skip dialogue lines in order to advance in the quest line. This is a very important result, as it is the case for most RPGs, and needs addressing.

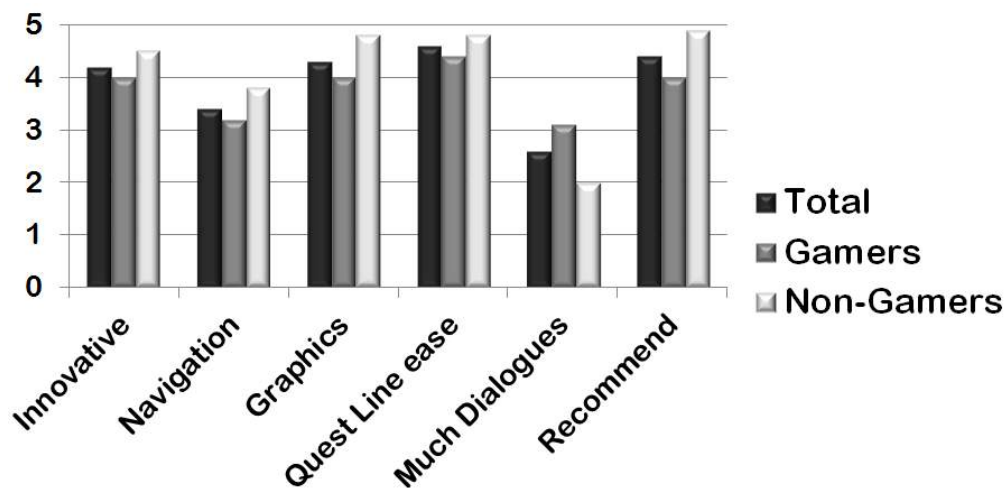
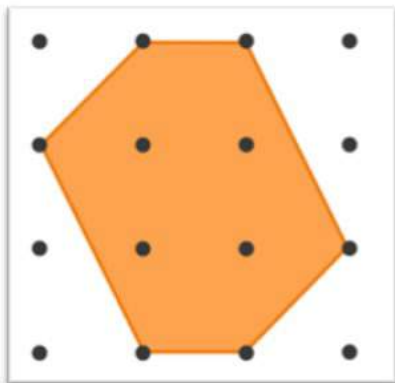


Figure 8: Comparison between gamers and non-gamers feedback

Overall, the participants were satisfied with the game and showed eagerness to play it. In most cases, they used calculator and notebook to solve the problems. Either they had a good mathematical background or little maths knowledge, they were all engaged with the questions and tried to find the right answers in a variety of ways. Fig. 9 shows an example of ways used to solve a particular question, using any method convenient and adjusted to their level of knowledge.



In this grid of dots, neighbouring dots are 1 unit apart horizontally and 1 unit apart vertically. What is the area of the orange figure?

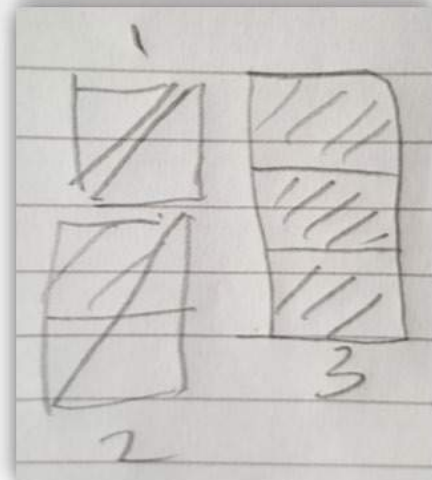
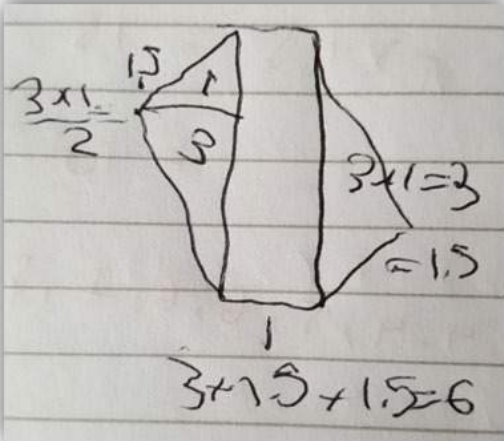
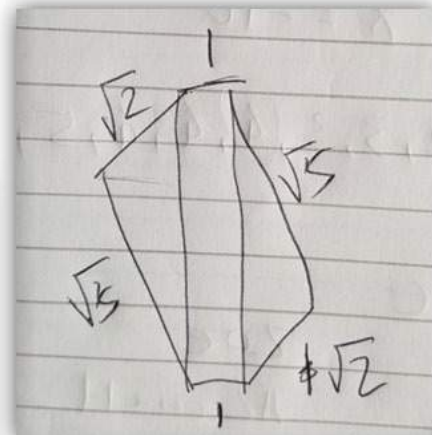
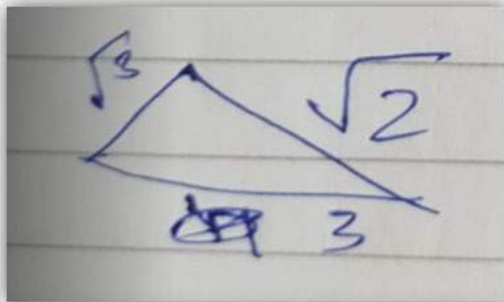


Figure 9: Solving a particular problem using various methods

Remarkably enough, people with a background not relevant to mathematics were particularly eager to understand every maths question. They were using the in-game billboards, google or even asked for explanation. As they stated, the game motivated them to get involved with a field that they were avoiding before.

Conclusion

At the current state, the mathematics integrated into the game are limited. The existing features in the combat and questing systems were simplified in order to test the effectiveness of certain methods. However, the Red Circle demo project provided insights for the built of the wider project in future. Some important outcomes are summarised below:

- The combat mechanics should be revised so that it does not disturb the player's entertainment. If mathematics is to be incorporated into the combat mechanics, it should be in a less complex way which would allow the player to either fight or answer questions, but not both at the same time.
- Mathematics integrated in map exploration and interactive items, like chests, is to be kept and developed further; for example, introducing time constraints and usable rewards following a correct answer.
- The multiple choice wheel function (fig. 5) is to be used but not in combat mechanics. Moreover, the level of the questions could be differentiated as:
 - *Easy*: numeracy and arithmetic questions
e.g. $2 \times 15 - 8 =$ Possible answers: **A) 14, B) 22, C) 23**
 - *Challenging*: GCSE level algebra
e.g. $\ln 1 =$ Possible answers: **A) 1, B) e , C) 0**
 $e^0 - 1 =$ Possible answers: **A) 0, B) $e - 1$, C) -1**
- The quest and story lines can be revised to embed activities and tasks that would indirectly involve the use of mathematics rather than simply ask direct questions. Different landscape areas could be involved with different mathematics topics.
- It was suggested to explore a feature where a teacher, for example, would be given the option to alter the mathematics questions or input new ones to account for their class needs.

Overall, it can be concluded that the Red Circle was an engaging demo game with great potential and could combine mathematics and a virtual fantasy environment into an entertaining experience. Further academic features along with various elements that are essential for fluid gameplay are next in the implementation scope in the future of the game's development.

Developing an online RPG, the future improvements are practically endless and there is plenty of room for creative thinking and innovative ideas. The wider project, however, does not aspire to be yet another commercial mathematics game among the plethora there is in the market. It rather aims to make use of a pre-existing recreational activity and seamlessly embed rigorous academic learning within, such that players are enjoying first and learning simultaneously by default.

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Impact of Virtual Reality (VR) and Augmented Reality (AR) on teachers delivering mathematics in further education

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Introduction

Virtual Reality (VR) and Augmented Reality (AR) technology have been in existence for a while, an immensely innovative development capable of transforming and enhancing life. Presently the gaming industry is making the most of this innovation and whilst this technology brings vast opportunities for all, the education sector has not fully embraced this or taken full advantage of the technology. There may be many reasons for this including lack of understanding and investment, teaching practitioners not skilled in using this technology or do not know how to best use these tools pedagogically. Other reasons could be to do with pressure of having to cover a curriculum within a tight timescale with a view to maximising learner outcomes which can often lead to being risk averse and perhaps some practitioners are set in their own ways, not willing to change.

Brent Start, an Adult and Community Learning provider for London Borough of Brent; Wembley, London, serving approximately 3,000 learners, in over 50 centre across Brent, have recently invested in developing a Virtual Learning Environment, which we fondly call The Virtual Pod (VP). The VR is fully kitted out with AR and VR technology along with a “Wonder Wall”; a fully immersive corner of the room where the floor and the two adjacent walls are fully interactive with integrated sound system. Brent Start recognises the need to develop digital technology and digital curriculum to enable Flip/Blended learning to flourish. Studies have shown the efficacy of Virtual Reality in the developing spatial ability (Durlach et al., 2000; Rizzo et.al., 1998)

We have started to convert our learning resources to digital resources so that learners are able to access learning from anywhere, anytime and anyplace. With the investment in AR and VR we are going a step further by enhancing learning through virtual stimulation and simulation, developing spatial skills and cognitive thinking without having to leave

the classroom and also bringing objects to life so that learners can truly visualise objects, thus provide better conceptual understanding.

However, to maximise the benefits of VR and AR for our learners, we need teachers to develop technical and pedagogical skills to make the most of this technology. Without practitioners being fully conversant with the technology, the learning will be ineffective. Teachers need to appreciate the complexity of the technology as well as the potential it brings; be aware of the pitfalls, learn how to make topics interactive and how to develop schemes of learning oriented around VR and AR. It is also acknowledged that teachers with the help of AR can raise interest and motivation of learners, enhance learning and raise better understanding of the subject matter (Yingprayoon, 2015)

Within Brent Start, along with other Skills for Life programmes, mathematics is a prominent curriculum area with high concentration of entry levels to level 2 learners from a various socio-economic backgrounds and from various ethnicity. For some learners, attending learning is an achievements whilst other aspire to attend university degrees. Many of our learners are challenged due to social, emotional and mental well-being and many also have numerous barriers to learning including technology. With this in mind and given the nature of our learners, lacking the willingness to engage in learning, it is essential that we are able to motivate and encourage learners to participate, excite them in the learning process whilst maintaining their commitment to successfully complete their programme of study, particularly for our female learners, which represents 86% of our intake. We know that maths is often frowned upon by many people, this may be due to many factors including poor personal experience in learning maths. Moreover, Geometric questions are in the main difficult and the subject matter is closely related to spatial skills and it is known that students have low achievement and have negative attitude towards geometry (Bako, 2003). Hence the need to look at new ways of improving teaching and learning that will capture their imagination.

Likewise, our teachers have differing views of educational technology, is not that they are averse to new technology or new ways of teaching, it is more about being confident, having the skills to navigate around the technology and being able to articulate and engage learners with their new pedagogical skills. In addition, it is also about demonstrating benefits of using new technology. Once practitioners are able to see the benefits not just only for their learners, but also for them in terms time and effort, they will embrace this change which will be a positive one.

Method

So in order to maximise the use of VR and AR technology, we have developed a small but focused study to ascertain the impact of VR and AR on teachers in delivering Mathematics (3D shapes) with a view to see how teachers change their pedagogy. By working in 3D space, complex 3D problems may be understood better and quicker than traditional methods (Kaufmann 2009).

We will use the Class VR Technology as the VR & AR tool and use resources developed internally using the software Paint 3D, which is compatible with Class VR, to conduct this research.

The research will focus on 6 teachers using VR and AR technology and will collect their feedback and views and how VR and AR has shaped their thinking in their teaching practice. In addition, we will collect feedback from other experts.

Workshop

In the workshops, we will be share some of the findings and advise delegates on some of the things we have learnt, we will also bring along the hardware (VR and AR equipment) together with curriculum resources for delegates to have hands-on experience in using this technology.

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Make Your Own Escape Room

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Introduction

Escape rooms have grown in popularity in the past few years. At their core, escape rooms are games in which players need to complete a series of challenges to win. When the first generation of escape rooms focussed on difficult logic puzzles, escape rooms today have evolved into fully immersive environments with high quality props and effects (Wiemker, Elumir & Clare, 2015).

Escape rooms encourage players to think creatively and engage in critical thinking. Solving a puzzle and ultimately winning will require individuals to work on the puzzles using multiple approaches to knowledge.

Escape rooms help develop skills in team work, creative problem solving and critical thinking. Considering an escape room can be themed with almost any topic, this makes it appropriate for the classroom. Educators at all levels can benefit from the use of escape rooms from primary levels graduate level.

Method

Escape rooms are booming. How nice would it be if you can use one in your math lessons.

The skills the student needs are: searching, observation, discernment, correlation, memorization, math, words, pattern recognition, compartmentalization. All skills that are very useful for numeracy.

In this workshop we teach you how to build your own mobile escape room, to be used as a motivating activity in your classroom. During the workshop we will do several logical assignments with the aim to unlock boxes. We explain the format that we used successfully in several workshops in The Netherlands.

Expected findings

You can use our format to finish the escape room you made a start with during the workshop.

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*Markus Wiemker, Errol Elumir, Adam Clare, November 2015, Escape Room Games: “Can you transform an unpleasant situation into a pleasant one?”

Brainstorming on a Numeracy Framework into the 21st century

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In a recently started Erasmus+ project four countries are working together to design a Common European Numeracy Framework (CENF). Considering numeracy as a social practice seems to be the most promising way forward to battle low numeracy and empower adults with a broad and effective repertoire of numerate behaviour to cope with situations in work and daily life. Therefore, a numeracy framework should contain much more than only content descriptions. Incorporating dispositions, attitudes, higher order skills, and affective aspects is as important. Such an elaborated framework can inform more multifaceted decisions on educational arrangements for adults who want to improve their numeracy behaviour repertoire to better cope with the quantitative problems in work and private life or to more fully and critically participate in the democratic processes in society. In the workshop we will brainstorm, discuss, and design elements of a “numeracy-as-a-social-practice” framework.

Introduction

In a recently started Erasmus+ project four countries - The Netherlands, Austria, Spain, and Ireland - are working together to design a Common European Numeracy Framework (CENF) and a set of professional development modules (PDM) for teachers and volunteers who work with groups of adults to improve, enrich and facilitate their numerate behaviours in situations they encounter in their daily life.

The driving force behind this endeavour is that too many European citizens lack the necessary numeracy competencies to participate autonomously and effectively in our technologized and number-drenched society. Consequently many citizens are overlooked for certain jobs and have problems in their daily life, dealing with the abundance of number-related circumstances (see Hoogland, 2018). The results of the last

PIAAC survey (OECD, 2012; OECD, 2016) show that for almost all participating countries in PIAAC 10% of the (potential) working population have numeracy levels below level 2 of a 6-point scale. These results on numeracy give rise to serious cause for concern for the future economic development of Europe. This is an even more pressing issue since the amount of numerical data that needs to be interpreted and used is rapidly rising due to technological developments and the prevalence of (big) data.

Theoretical background

The design of the framework and the modules is rigorously grounded in literature reviews, Europe-broad surveys, and professional development trials, to build upon the vast experiences of people in the field, the conceptual developments in adult numeracy education as they have been blossoming for the last 25 years, and the societal demands of the 21st century (Schwab, 2016; Voogt & Pareja Roblin, 2012). Furthermore the PIAAC Numeracy Assessment Framework (Tout et al., 2017) is used as a source of inspiration.

Considering numeracy as a social practice seems to be the most promising way forward to battle low numeracy and empower adults with a broad and effective repertoire of numerate behaviour to cope with situations in work and daily life. We cite Oughton (2013) : “A social practice view of numeracy not only takes into account the different contexts in which numeracy is practised, such as school, college, work and home, but also how people’s life and histories, goals, values and attitudes will influence the way they carry out numeracy (p16). An even richer collection of ideas on this approach can be found in Yasukawa, Rogers, Jackson, and Street (2018).

Among researchers and practitioners there is a growing consensus that a numeracy framework which describes numerate behaviour and numeracy practices should contain much more than only content descriptions. As important are dispositions, attitudes, higher order skills, and aspects of agency, and self-efficacy.

It is quite a challenge how to incorporate all these elements in a consistent and workable framework, which can inform decisions on educational arrangements for adults who want to improve their numeracy repertoire to better cope with the quantitative problems in work and private life or to more fully and critically participate in the democratic processes in society.

Method

The workshop is an elaboration of the backgrounds and ideas presented in the plenary talk “Adult numeracy practices in the 21st century: imperative implications for education”. In the workshop we will brainstorm and discuss the choices that can be made

in the design of a “numeracy-as-a-social-practice” framework. But more important, we will also collaboratively design concrete descriptions of numeracy behaviour that can substantiate the more general ideas of the developing framework. We will dwell upon the expertise gathered at ALM to make the next steps in the development of a CENF.

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Trade Union Learning and the Numerate Environment

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In this workshop we discussed the notion of a 'numerate environment'. This relates to long-standing efforts of mathematics education researchers to characterise the everyday context(s) of adults' lives, and the way that this 'situates' ('surrounds' or 'grounds') the numerate activities of the typical adult (e.g. Lave, 1988; Evans, Wedege & Yasukawa, 2013).

We consider examples of different types of settings where adults might be expected to exercise their numeracy in contemporary industrial societies. In particular, we discussed a range of environments that could be classified as numerate, including the conversion of a country's currency system (Slovakia) and the spatial challenges of changing driving on the left-hand side of the road to the right-hand side (Sweden). We then focused on the characteristics of a different sort of collective environment, that of trade unions (TU), in UK industry where fellow TU members are encouraged and motivated to improve their maths skills up to level 2 (equivalent to GCSE in the UK). (Kelly, 2018).

Participants were able to explore the notion of the numerate environment and use it to analyse other examples, identifying the demands, opportunities, and supports of these particular contexts. They were encouraged to draw attention to similarities and differences with other successful learning contexts for adults, and to propose the design of other effective numerate environments.

Developing the idea of a 'numerate environment'

Participants were introduced to the notion of the numerate environment by considering research by Evans, Yasukawa, Mallows and Crease (2017) who drew on a discussion of the 'literate environment' (EU High Level Group, 2012) as a web of 'literate practices' which forms the context for an adult's activities. This helps one to characterise the 'numerate environment' faced by a typical adult, in the sense of the *demands*, *opportunities*, and *supports* for numeracy provided by their situation. Initially, adults are considered as isolated individuals, surrounded by a relatively stable environment, which is also reasonably uniform across a population of individuals. However, current work is now investigating the collective numerate environment provided by a situation where an entire society undergoes a significant change, such as the conversion from a national currency to the euro (Kubascikova, Evans and Khan, 2019).

Considering applications of the idea

We then discussed a different sort of collective environment, that of trade unions, in a particular industry (or group of similar industries), in the UK (Kelly, 2018). We aimed to sketch the numerate environment that presents itself to this group of trade unionists in the workplace. In particular, we considered the pedagogic context, that of the adult maths learning environment provided by trade union (TU) sponsored courses in England at the current time, where fellow members are encouraged and motivated to improve their maths skills up to level 2 (equivalent to GCSE in the UK).

We explored trade unions' interest in education in the UK, pointing out that it dates back to their development in the late nineteenth century. However, the current opportunity for TU members to learn mathematics arose in the late 1990s, when the new Labour Government sought to address the national basic skills shortage in mathematics and English by investing in a range of adult education settings, including workplace learning thorough TUs. Later research (Hume et al., 2018, p. 77) into basic skills education in the workplace found that learning resourced through the Union Learning Fund (ULF), supported through learning centres and Union Learning Representatives (ULRs), was one of the 'few effective existing models of work-based support for mathematics and English', highlighting the role of peer support.

We also explored the pedagogic characteristics of the TU numerate environment. Kelly's (2018) research highlights several key factors in encouraging TU members to re-engage with learning, including the *support* of ULRs, *trust* in the safety provided by the TU setting, and the *active support* of other members within the learning group. Learners identified the significance of experiencing a different learning approach to that previously experienced (often in more formal contexts such as school or college). Learners perceived the TU numerate context to be more supportive, set up in smaller classes where learners helped each other and where they could talk openly about mathematics and their problems, with no fear of humiliation. The numerate context was described as relaxed, taking place in meeting rooms in the workplace, hence learning mathematics in non-traditional contexts using non-formal or informal ways of learning, that in this case reflected workplace meetings rather than teacher-led classrooms.

They also spoke about the mathematics being more relevant, in the sense that topics (where possible) related to practical applications (such as building a shed), financial concerns (e.g. interest rates), or linked to trade union issues (such as Health and Safety).

Rather than always considering the decontextualised numeracy competence of individuals, the workshop enabled members to consider numerate environments as larger systems of affordances - opportunities, supports, and demands.

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Presentation of the winners of the BVMBO contest “Best Math Idea 2019”

Kooske Franken

Albeda

Every year the Dutch organization of Dutch Math teachers (BVMBO) and Practoraat Rekenen organize a contest for Dutch math teachers in vocational education, called The Best Math Idea. Three prize-winners win tickets to the ALM, also hotel- and travelling expenses. This year the winners are:

Anne Marleen Tigelaar, ROC Friesland. She developed three digital lesson for her students in the tourist business. The students have to make all kinds of math assignments for the resort of the future and have to organize a trip for tourists called: Visit Holland.

Fedor Kerkhof, ROC De Leijgraaf. Fedor is a math teacher for students in the carpenters industry and he designed a technical assignment called The Wheel of Fortune.

Martijn van der Linden, Summa College The idea of Martijn is called Math Lab. He designed 4 challenges for teams. For every challenge the teams can win badges. The team who wins the most of the badges are the winners.

Posters

Reflections on Using a Digital Collaborative Classroom to Teach Mathematics to Adults

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Introduction

When I first saw one of the new “collaboration classrooms” in our university’s new building two years ago, I immediately knew that I wanted to try using them. I did not realize then what an impact that would have on how I teach and even what I teach. Could these types of rooms be the future of mathematics education, particularly for adult learners? This presentation includes benefits and lessons learned and cautions for future use.

Method

First, here is a description of the rooms. They are designed for collaboration among students which is facilitated through the use of digital technology. The rooms have a number of “pods” around the outside of the room that each seat up to six students. Each pod has tables and chairs, a large white board, and a monitor. Students can plug in a laptop or mobile phone to their monitor (or, as is the case with one of the rooms, connect wirelessly through a mobile phone app). There is no front of the room but there is an instructor station in one corner through which PowerPoints or websites can be broadcast to all of the students’ monitors. It is also possible to broadcast one pod’s screen display to the other pods. The rooms have wireless internet access

The course I taught was Quantitative Reasoning which is a required mathematics course for non-STEM students, all of whom are adults with most in their early to mid twenties with a typical age range from 18 to 45 years old.

Findings

I have been greatly encouraged by what I have seen. Student reviews were very positive about the rooms and how working with classmates helped them considerably. I found myself thinking differently about my role as a teacher and the students' role as learners.

Here are positive aspects of the room design:

1. To take advantage of the room, I had to approach teaching with the following in mind: lecturing needs to be minimized; class time should center around group projects; students would be asked to help each other learn the course objectives; students would be encouraged to develop and share methods of solutions; and real, authentic problems should be used.
2. For students to take advantage of the room, they need to: be willing ask for help when they have questions and provide help when they see that someone needs help; have a device to access the internet (although not required); and engage in the learning activities (I put the responsibility for their learning on them).
3. The configuration of furniture in the room which allows students to see and communicate with each other helps to establish a learning community in the classroom.
4. Each pod of students can share their work with other pods through the whiteboards or their screen displays. It is easy as a teacher to stand in the center and point out different assumptions, approaches, etc. of the pods.
5. Because virtually all students have a smart phone, tablet, or laptop with them; I can have them search for the information themselves, as they would on their own in real life, and not provide them everything they need. This has pushed me to provide authentic problems. I also teach internet search techniques.
6. Traditional mathematics instruction in the United States seems to involve a lot of doing problems by hand. But in this non-traditional room, I stress the value of using mobile apps and various calculators and how to interpret the results they see.
7. With no front of the room, I had to put my content on PowerPoint slides. These are posted in the learning management system so that students have access to them. Some students use their tablets to take notes on the slides. Busy adult learners who occasionally miss class can still view the slides.

8. Younger students whose high school mathematics is more recent frequently help older students but in some authentic problems the older students have the advantage due to their life experience and can help the younger students (for example, mortgages).
9. Productive persistence by students in problem solving is seen as an important quality in learning. Some students persist longer in this classroom because they have the support of their pod-mates.

Here are some cautions:

- Some students have learned to survive math classes by taking a lot of notes and memorizing steps. This collaborative approach makes some students uncomfortable, at least at first.
- The rooms have their share of technical problems so rapid support is needed.
- While more and more learners have access to the internet, there can still be a digital divide.
- Students with anxiety issues may have trouble in a room and teaching philosophy that requires this level of collaboration.

E-learning – different ways of learning numeracy

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Introduction

Skills Norway, the Norwegian Directorate for Lifelong Learning, works to ensure that adults have access to skills training. The current focus area is giving adults various methods of training and learning which fits their hectic lifestyle. One such method has been online resources and training programs. In the past year, Skills Norway has developed various online resources for training basic skills, including literacy, digital skills and numeracy. Though the focus areas in the different resources varies, they all contain parts numeracy. In addition, Skills Norway was one of several partners involved in the Erasmus + project “Managing Money” which ended fall of 2018 and produced an app, website and teacher resources in financial literacy. All these are part of numeracy in a digital age. This presentation includes method, benefits and practical applications as well as a link to the English versions

Method

The e-learning resources presented in the poster are all based on previous resources developed by Skills Norway and various partners. To make sure the tasks are up to date, several math teachers working with adults daily have been involved in creating the tasks, testing the resources with their students and given feedback. Even though the resources vary from literacy, digital skills and numeracy, they all contain numeracy at some level. Literacy includes reading charts and graph while digital skills includes online banking and shopping.

The Managing Money resources were the result of a three-year-long Erasmus + project with different partners in different European countries. The initial focus of the project was to find what type of resources already existed, and then focus on what was wanted and needed. The project conducted a needs analysis and interviewed different

stakeholders to map the need as well as possible solutions. In addition to an app for adults with different avatars saving toward a goal, the project also developed a curriculum, and resources to be used both in and outside a classroom.

Lesson Learned

The various resources have been launched throughout late 2018 and 2019 and with the initial feedback, version 2.0 have either launched or will be launched in the few coming months. In Norway, close to 100 % of the population has access to online resources at any time meaning the digital world and age is available for those who want to be part of it. Making resources available online is a way to ensure that those who need it get access to it. Not everyone can find time to take classes, or want to buy books, but online resources are there when you need it.

Practical Applications

The resources are available for anyone to use. The Skills Norway resources are available in Norwegian only, while the Managing Money resources are available in English, German, Dutch, Slovenian and Norwegian.

References

Norwegian site (the original website)

www.kompetansenorge.no

English site

www.skillsnorway.no

All basic skills:

<https://www.kompetansenorge.no/kompetanseporten/>

Financial literacy:

<http://managing-money.eu/>

<https://www.kompetansenorge.no/personligokonomi>

“Math-Art Walks” – The Art of Looking at Public Art and Architecture with Mathematical Eyes

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Introduction

In 2015, I participated in the ALM22 Conference in Washington D.C. having the theme “Opening Our Math Eyes To See Math In Everything We Do”. All the inspiring keynote speeches and presentations I got to take part in opened my “math-eyes” as well. Back in Sweden, I started to work out a project proposal, The Art of looking at public art and architecture with mathematical eyes. I was granted a scholarship from Gudrun Malmers Foundation and a teacher colleague, Bengt Eklund, joined the project that started in 2018.

The project aims to encourage students to see, discover and learn math through art and architecture while learning about the culture and history of their home town. In practice, this is done by “Math-Art walks” with the support of a study compendium that I developed based on the Swedish mathematics curricula (Skolverket, 2012, rev.2017), ZalayaBáez’s (2004) classification of mathematical sculpture, and art history. The relationship between art, architecture and mathematics is expressed in the aims of the mathematics curricula of adult education, compulsory school, and upper secondary school. For example, teaching mathematics in compulsory school should aim at:

helping the pupils to develop knowledge of mathematics and its use in everyday life and in different subject areas. Teaching should help pupils to develop their interest in mathematics and confidence in their own ability to use it in different contexts. It should also provide pupils with the opportunity to experience aesthetic values in mathematical patterns, forms and relationships. (Skolverket, 2012, rev. 2017).

The upper secondary curriculum in mathematics describe that:

Teaching should cover a variety of working forms and methods of working, where investigative activities form a part. Where appropriate, teaching should take place

in environments that are relevant and closely related to praxis. Teaching should give students the opportunity to communicate using different forms of expression. In addition, it should provide students with challenges, as well as experience in the logic, generalisability, creative qualities and multifaceted nature of mathematics. teaching should provide students with challenges, as well as experience in the logic, generalisability, creative qualities and multifaceted nature of mathematics. (Skolverket, 2012).

My intention with the project is to visualize how integrating local art and culture in formal math education may open, not only “Math Eyes”, but “Math-Art-Culture Eyes”.

Method

As my practice is in the city of Lund, I have chosen to focus on public art and sculptures found here. All in all, the project includes 76 sculptures and buildings. To create a structure for the Math-Art Walks, the city has been divided into 20 geographical areas. For each sculpture and building, we have compiled general information about the object and tasks that, as a whole, cover many of the knowledge requirements that the students encounter in their courses. Engaging in a Math-Art Walk requires from an hour up to a day depending on how many objects are included in the walk. I have developed a compendium to be used during the walk comprising a short description of art movements, ZalayaBáez’s classification of mathematical sculptures, a set of tasks associated to each sculpture and building, and a response template.

Overall, the first and last task for each sculpture and building are identical. The first task is divided into smaller exercises. In the first, the students have to mention the name of the sculpture or building, who made it, when it was made, if it is site-specific, and what they think the artist or architect wanted to express. For the sculptures, the students also have to describe the art work with words, marking those they find mathematical. They are encouraged to identify the art movement (ism) and to find the mathematics in the object by using ZalayaBáez’s classification. The last task is to formulate a mathematical exercise involving the sculpture or building. In between the first and last task, there are specific tasks with different mathematical content.

Invitation to a discussion

I would be very grateful for comments that can develop and improve the project as well as your thoughts about if you could bring the concept of the project to your workplace.

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