

Welcome

Opus et Educatio is an online journal first published in 2014, in Hungarian, and now – from the beginning of 2015 – also available in English. We hope its existence and envisioned development will be justified by the content of future issues. We are aiming at addressing topics that will interest many, in particular those who are involved in the world of work and the human factor, and their development at a professional level. However, this journal is not an exercise in *l’art pour l’art*, nor is it a forum where trendy issues are analysed or topics are selected in the interests of achieving specific communication goals. Perhaps the simplest definition of our objectives is that we wish to publish independent professional papers and generate discussion – yet these aspirations can only be realized when we indeed have many readers who regularly visit the portal of our online journal and actively contribute to the process by commenting, thus facilitating up-to-date and lively intercourse.

We intend to publish quality content by having the papers for our main columns – *Studies* and *Eye Opener* – proofed by experts who do not personally know the authors. *Studies* will present articles by acknowledged experts, researchers, and teachers which define strategies, raise issues, or analyse problems. *Eye Opener*, on the other hand, will host papers dealing with novel initiatives, innovations, and practical issues with the intention of informing an international professional audience.

Following the traditions of the Budapest University of Technology and Economics, our Department is committed to quality and always observes basic communication standards while also complying with the requirements of scientific publications. This is why the Department not only edits the journal in regard to its content and format but also, representing a community committed to education, undertakes to use the latest results of network learning when providing information for a broadly-interpreted professional audience. For this reason, we consider it important to include a column in each issue that reviews new research, books, and other publications. With this formal arrangement we are endeavouring to reference the three pillars of professional communication: theory, practice (and their complex interactions), and critical reviews.

Last but not least, a word about the title. **Opus et Educatio**, while having an archaic or even conservative ring to it, incorporates an important message. Its meaning, “Work and Education”, implies more than a traditional vocational training profile, being the motto that has distinguished our Department, “the editorial nerve centre”, from other workshops of educational science and other departments focusing on education for almost one and a half centuries. Obviously, our initiative will only truly bear fruit if it meets readers’ expectations. Furthermore, editors and readers will jointly profit, if the content, style, and image of the journal is formulated by means of a mutual effort. We are thus asking readers to be our partners in a creative venture. The measure of our success will be the number of regular readers who not only have **Opus et Educatio** on their bookmarks bar, but who also play an active part in this new enterprise, which begins with our first issue.

VÁMOS, Tibor

THE FUTURE OF HUMAN ROLES IN THE EMERGING AGE OF INFORMATION

Introduction: A new turning point in history

Allow me to open with a rather presumptuous statement: Due to the progress of our technology, mankind has reached a new turning point in history.

From the very beginning of civilization, machine power has gradually replaced the physical roles formerly fulfilled by humans or animals until it has come to predominate in the tasks concerning the majority of mankind. Our discipline has continued this radical change in all kinds of undertakings excepting those requiring human creativity and empathy. The ongoing third industrial revolution is accelerating this shift with economic rationality – in present-day, ordinary workplaces, sophisticated, smart automation is increasingly cheaper, more reliable, and more easily manipulated in comparison with the human workforce. The earlier shifts from agriculture to industry and services occurred according to ruthless social forces, resulting in tragedies for masses of people but new opportunities for those who were skilled and fortunate enough to be able to adapt. The changes in social structures and in technology worked conversely.

Some antecedents

The feeling of this historical relevance goes back to ancient times. To quote Aristotle¹, if every instrument could accomplish its own work, obeying or anticipating the will of others, like the statues of Daedalus, or the tripods of Hephaestus, which, says the poet, “of their own accord entered the assembly of the Gods,” and if, in like manner, the shuttle would weave and the plectrum touch the lyre without a hand to guide them, chief workmen would not want servants, nor masters slaves.

Taking a great leap in time to a little more than one and a half centuries ago, Marx² comments:

But to the degree that large industry develops, the creation of real wealth comes to depend less on labour time and on the amount of labour employed than on the power of the agencies set in motion during labour time... but depends rather on the general state of science and on the progress of technology, or the application of this science to production. ... Agriculture, e.g., becomes merely the application of the science of material metabolism, its regulation for the greatest advantage of the entire body of society. ... Labour no longer appears so much to be included within the production process; rather, the human being comes to relate more as watchman and regulator to

¹ Aristotle. *Politics First Book*, 1253b. (Trans. Benjamin Jowett.) Internet Classics Archive

² Marx, Karl. *Grundrisse*, Notebook VII. (Trans. Martin Nicolaus.)

http://www.marxists.org/archive/marx/works/download/Marx_Grundrisse.pdf

the production process itself. ... [The worker] steps to the side of the production process instead of being its chief actor. In this transformation, it is neither the direct human labour he himself performs, nor the time during which he works, but rather the appropriation of his own general productive power, his understanding of nature and his mastery over it... it is, in a word, the development of the social individual which appears as the great foundation-stone of production and of wealth.

I must also refer here to Keynes³, who in the time of the Great Depression had a message for us in his *Economic Possibilities for our Grandchildren* (1930):

In quite a few years – in our own lifetimes I mean – we may be able to perform all the operations of agriculture, mining, and manufacture with a quarter of the human effort to which we have been accustomed. ... We are being afflicted with a new disease of which some readers may not yet have heard the name, but of which they will hear a great deal in the years to come – namely, technological unemployment. This means unemployment due to our discovery of means of economising the use of labour outrunning the pace at which we can find new uses for labour.

But this is only a temporary phase of maladjustment. All this means in the long run [is] that mankind is solving its economic problem. I would predict that the standard of life in progressive countries one hundred years hence will be between four and eight times as high as it is to-day. There would be nothing surprising in this even in the light of our present knowledge. It would not be foolish to contemplate the possibility of a far greater progress still. ...

I draw the conclusion that, assuming no important wars and no important increase in population, the economic problem may be solved, or be at least within sight of solution, within a hundred years. This means that the economic problem is not – if we look into the future – the permanent problem of the human race.

Turning point: The price of working power

This is where we stand at present. According to the above statement, a radical change is taking place concerning human roles, in the relationship between humans and work, and in the shortages of goods necessary for global welfare. Now there are many more palliatives – a far greater range of medical, psychological, and social solutions – to the problems that were previously a curse of human coexistence. Although this change has been in progress for over two centuries now, it is soon going to reach a turning point due to our technological progress. This is why it is our professional obligation to draw attention to this circumstance.

The turning point should be the moment when the cost of any available and appropriate human labour force is higher than that of the automated machine substitute. As will be discussed later in greater detail, the problem is less that of unemployment but rather that of re-employment, i.e. the aforementioned human role.

³ Keynes, John Maynard, 1963. *Essays in Persuasion*. New York: W.W. Norton & Co., pp. 358-373.

A “rough” calculation

Let us attempt a small calculation. The analogy is the car. The car is basically a mechanical device, in which respect it is no less complex than any robot – nor, with its current array of electronic, sensory, and control features, is it any less sophisticated. Due to mass production and modular design, a mid-range car is available for around USD 20,000. Producers offer a five to seven-year guarantee. If we suppose only four years of service for a robot at about 5000 hours a year (fewer than two shifts, no free days), this means an investment of \$1 per hour. That could be calculated as the wage equivalent! The minimum wage in the industrial regions of China⁴ is now at the same level! If we remain with the car analogy, support, maintenance, and other expenses cannot be more than about the same, although they are presumably much lower. Much lower than the overheads, social expenses, and social problems related to the human workforce⁵.

This is a cruel calculation, as inhuman as it is common in the profit or power oriented world. Its reality is undeniable, yet such a reality could only be upheld in the cases of despotic dictatorships or social retrogression.

The problem primarily affects the low-paid population, those mostly working in mass production industries and related occupations, yet it further influences the future of the present underclass⁶ all over the world and, in developing countries, those millions who suffer from or enjoy the outsourcing processes of wealthier countries.

Unemployment, dubious approaches, open problems

The problem of unemployment is even more far-reaching than as it was outlined in the quotation from Keynes. In our times, the questions it poses are much more broadly discussed and they occupy politicians, economists, journalists, and the general public alike. We on the side of creating technology should also contribute with our points of view.

The first question refers to the nature of current and future unemployment – is it generally increasing, or does it only fluctuate according to economic cycles?

Why does unemployment affect the younger generation so significantly? Is this a result of an “easy-life” social phenomenon or a sign of generational oppositions? Is it in any way connected to advances in technology?

How structural is it – due to changes in conventional technologies, and rapidly obsolescing professional knowledge and learning preparation methods?

Does a danger of some kind of modern Luddism exist, and is that related to political trends in the artificial slowdown of the introduction of new technology?

Are there any forecasts of how the restructuring of employment can maintain or upset current balances? Are service opportunities able to absorb the masses freed from traditional production? Does the increasing automation of services influence this trend?

⁴ [http://en.wikipedia.org/wiki/List_of_minimum_wages_in_China_\(PRC\)](http://en.wikipedia.org/wiki/List_of_minimum_wages_in_China_(PRC))

⁵ The extrapolation of future smart robot prices for the next one-two decades is rather cautious. Intelligent educational robots with visual and tactile feedback today cost about USD 1500; flexible, multipurpose industrial robots start at about USD 30,000. Current price lists can be found on the web using the search term “robot prices”.

⁶ Myrdal, Gunnar, 1963. *Challenge to Affluence*. New York, NY: Random House, p.10: “An underprivileged class of unemployed, unemployables and underemployed who are more and more hopelessly set apart from the nation at large and do not share in its life, its ambitions and its achievements.”

How does the restructuring of employment influence social inequality (e.g. as measured by the GINI index)?

All these questions are more or less influenced by the achievements of our technology of automation and it is for this reason that the answers should be firmly based on those phenomena.

Contradictory answers

The current literature on this issue is rather contradictory. Most of it argues with statistics implying that unemployment is basically influenced by economic crises and that in normal conditions new technologies create sufficient new jobs to absorb the fallout. I cite only a few representative opinions from the abundant material available.⁷

There is even less consensus regarding the root causes of the specific issue of unemployment among young people. Some authors, the cited sources included, attempt to explain it by alluding to demographics and social behaviour; others refer to inappropriate or inadequate education.

Several authors of markedly different professional standing suggest that the changes in social and economic systems are consequences and requirements of the future. Paul Krugman is one of the most competent daily commentators. There is a contemporary reference to Marx by Chris Farrell⁸. A philosopher's view is illustrated in a blog by Michael Sanders⁹ and Karl Smith contemplates the borders between robot fiction and reality¹⁰.

According to my own analysis, the period of radical changes is to be expected within one or two decades, as the economic consequences of the changes become irreversible.

As previously mentioned, the spectre of the Luddites, the early 19th century machine-breakers, looms anew in modern forms. Some politicians recommend artificial slowdowns in the introduction of human-replacing technologies. Our reply to this is borrowed from John von Neumann: "For progress there is no cure. Any attempt to find automatically safe channels for the present explosive variety of progress must lead to frustration."¹¹

⁷ Robert Skidelsky, Professor Emeritus of Political Economy, Warwick University:

Recently, automation in manufacturing has expanded even to areas where labor has been relatively cheap. In 2011, Chinese companies spent ¥8 billion (\$1.3 billion) on industrial robots. Foxconn, which build iPads for Apple, hopes to have their first fully automated plant in operation sometime in the next 5-10 years.

Now the substitution of capital for labor is moving beyond manufacturing. The most mundane example is one you will see in every supermarket: checkout staff replaced by a single employee monitoring a bank of self-service machines.

...structural unemployment – the unemployment that remains even after economies have recovered – has been on an upward trend over the last 25 years. We are finding it increasingly difficult to keep unemployment down.

Chiodo, Abbigail J. & Owyang, Michael T., 2001. *Low Unemployment: Old Dogs or New Tricks?* Federal Reserve Bank of St Louis, [The Regional Economist, October 2001](#)

Paul Krugman, Nobel Prize Winner and Op-Ed Columnist for The New York Times, August 3, 2013, 2:27 pm: [129 Comments:Structural Humbug](#)

Borenstein, Jason. Robots and the changing workforce. *AI and Society*, Volume 87/1, Feb. 2011, pp. 87-93

⁸ Chris Farrell: What would Karl Marx think?, Bloomberg Businessweek, June 27, 2013

⁹ Sanders, Michael. **Seizing the Utopian Possibilities of our Robot Future.** *The Philosopher's Beard*, <http://www.philosophersbeard.org/2013/05/avoiding-our-dystopian-robot-future.html>, May 31, 2013

¹⁰ Smith, Karl. Inequality in the Robot Future. *Forbes*, May 13, 2013

¹¹ von Neumann, John. Can We Survive Technology? *Fortune*, June, 1955. Reprinted in Brody-Vámos: *The Neumann Compendium*, World Scientific, 1995, pp. 658-673

Beyond technology

This issue goes further than technology. It is the question of the human role in an abundant society where automatic or automation-driven production and other economic activities require the input of only a minority of the human population and, generally, only a minimum of human effort. Several visions are now taking shape in earnest. One is that of the foresight of Keynes, involving a radically shortened working time, reduced to about fifteen hours a week. The other extreme is the possibility of choosing non-working on a low income – one sufficient to ensure modest conditions for a life with dignity (guaranteed basic income)¹². What would life mean in such societies?

This problem is very old. It has been raised in numerous contexts: that of the beliefs of religions concerning the mission of mankind; in the social context of the gap between hard-working people and those able to enjoy life as a consequence of the former's toil; among the roles of different professions and the division of labour; and concerning the role of working as a main actor in human evolution, an emergent idea after Hegel¹³. All of these contexts are relevant at the advent of a technology-created affluent society – with opportunities for improvement appearing alongside the potential decline of traditional ethical and cultural values – where the avenues of such contexts and the social relevance of those avenues are supported, and in some degree defined, by technology.

According to the income gap as measured by the GINI index, social inequalities are growing larger. This is a widely-discussed problem. Another gap will emerge between those performing familiar tasks over a shorter working time and those who must struggle with the ever-growing ocean of information. These latter are the innovators, entrepreneurs, pioneers of research and development, and managers of various human organizations and large-scale systems, who work at least two shifts a day and always have trouble with time schedules. The emerging instruments of information processing, mostly referred to as Artificial Intelligence, may be helpful but are unable to solve the problem linked to human perception and creativity.

The answers are vague and they vary from one economic and cultural environment to another; nonetheless, I am certain that we creators and distributors of this new world of technology, the imminent radical change in basic human circumstances, have a role to play in finding solutions. Firstly, reliable information concerning realistic eventualities must be gathered. Secondly, the introduction of the new technology must be combined with social analyses, similar to the usual economic treatment of any technological innovation. We have to participate in those analyses and prepare our students and professionals for their roles in the same way as we have worked on economic impacts.

The cultural-geographical dialogue

The present conference could initiate fertile dialogues. It is aimed at the broad spectrum of people involved in technology and the social sciences, and focuses on views from the currently most relevant, creative civilizations which, on the one hand, shape the changes and, on the other hand, will be most affected by the consequences of those changes. These

¹² Chollett, Mona. Money to live. *Le Monde Diplomatique*, English Edition, May, 2013

¹³ Hegel, Georg Wilhelm Friedrich. *Phenomenology of Spirit*. (Trans. A.V. Miller.) www.scribd.com/doc/.../free_ebook

are the historically great civilizations and the majority of present mankind: China, India, and the Atlantics (Europe and most of America being included in this latter group). Such dialogues could be fertile due to a common concept of reality, that of the progress of technology.

Let us return to the advice of von Neumann:

The one solid fact is that the difficulties are due to an evolution that, while useful and constructive, is also dangerous. Can we produce the required adjustments with the necessary speed? The most hopeful answer is that the human species has been subjected to similar tests before and seems to have a congenital ability to come through, after varying amounts of trouble. To ask in advance for a complete recipe would be unreasonable. We can specify only the human qualities required: patience, flexibility, intelligence.

Conclusion

The advent of an epoch of automation in production and all traditional activities on a hitherto unseen scale is inevitably emerging. New human roles and relationships are developing, bearing blessings and ills of varying degree. The constructive, realistic approach of engineering, in addition to discourse within several related sciences, is indispensable.

The transformations in question, just like with all previous great historical changes, will take time (the inertia of societies lasts longer than the time constants of technological development – sometimes for several generations). This colloquium, and many similar ones, may be a significant and responsible step towards confronting the issues such changes raise.

SZÚCS, András

EUROPEAN POLICY AND ICT DEVELOPMENTS IN LEARNING, 2015
A CHANGING SOCIO-ECONOMIC CONTEXT AND TECHNOLOGICAL ENVIRONMENT

Introduction: Complex Changes, accelerated transformation

Due to the coincidence of several transitional factors, the state of ICT in education and training is most complex, as are the European policies related to it. The previous two to three years have been characterized by intensive changes in the fields of ICT-enhanced learning, learning innovation, and open educational resources.

Important contributory factors were the hectic period of the European Parliament elections in 2014 and the medium-term planning processes in the EU, linked to the programme development and budgeting period of 2014-2020. As in many other fields, education, training, and youth included, complicated scenarios, concepts, and plans were elaborated in the think tanks of the European Commission and the policy-making bodies of the political parties.

This eventful period was accompanied by the finalization and presentation of comprehensive studies, reports, and papers prepared for the Commission by European think tanks, followed by academic and policy debates in the field of education. As interrelated streams, several analyses and observatory and foresight activities, and the presentation of results of strategic EU projects became available, and were disseminated and discussed in public forums, conferences, and seminars.

In parallel, several international organisations (OECD, UNESCO, EUA, the World Bank, and others) also published reviews and position papers on the themes of ICTs, learning innovation, and open education. Many national governments in Europe have also commissioned related strategic papers, studies, and periodic reports. With different perspectives, organizations in the corporate sector have also had a presence in the debates with their opinions and position papers. The increasing public interest towards open education in particular has generated countless articles in newspapers and journals, both in print and online.

The above activities have resulted in a continuum of papers, studies, statements, foresights, observatory reports, and project deliverables being presented and published in the last two years.

All these factors have initiated paradigm-changing transformations in recent years.

The ever-improving performance of mobile devices and the development of networking infrastructure have transformed the information society – ***generally outside institutional settings*** and often along unexpected pathways. This has led to the rapid spread of cutting-edge technologies, resulting in a spectacular increase in demand for them and in their use. The changing notion of access, accompanied by the increasing volume and improving quality of digital content, and the radically transforming habits and expectations of users have engendered new interpretations concerning several related concepts and have repositioned the social impact of ICTs in learning.

The period 2012-2014 was therefore a critical, rapidly changing, and turbulent period for ICT-supported learning and e-learning, including distance education and in particular Open Education. ***In 2015, we are at a “meta-stable point” of the development-change curve.***

Socio-economic environment: The education – employment context

In a world where “complexity becomes the new reality” (Conole, 2012) a proper understanding concerning which skills drive economic activity is essential. Technological development does not necessarily translate into economic growth and, in particular, jobs. Success is increasingly linked to ways of thinking and has more and more to do with values: technological knowledge and global thinking should act in synergy in the changing, accelerated, interconnected, multilingual world. The emergence of low-cost models in education presents a challenge for all sectors, particularly for universities.

The development of ICTs and new tools, and their increasing performance levels, power, and affordability, coupled with permanently upgrading networking capacities, are rapidly transforming the information society. This frequently occurs along unexpected lines and with a great diversity of scenarios, often incorporating all the implicit contradictions and provisionality of such phenomena.

Currently, under the impact of uninterrupted economic turmoil, the interconnected disquieting policy scenarios, and the resultant disruptive effects on society, the emphasis is on recovering growth and competitiveness in Europe. The considerations of human aspects, the desires of society, and the demands of the public sphere are increasingly less emphasized in policies and are losing their place in economic decisions. This is also reflected in the approach and perspective of the renewing EU programme until 2020, education included, and in the approach of the new European Commission, which started its work in late 2014 under the leadership of Jean-Claude Juncker.

Enhancing education providers’ job placement awareness, efforts for exit strategies from universities are becoming emphasized requests. Questions for the education sector such as how well training is translated into employment opportunities and how curricula can be translated into career guidance receive priority. Partnerships and apprenticeship programs are amongst the tools to be used much more often in order to overcome the existing discrepancies.

In the meantime, increasing attention is being devoted to the relationships between learning, living, and society, and to learning communities which extend beyond education, including the way learning is organized in different communities and spaces (intergenerational and cross-cultural, learning).

EU policy elements

While there is a growing public interest in and high demand worldwide for knowledge and education, and while the intensive social media movements are familiar with both the provider and user communities, the common issue of emerging skills deficit contributes to the critical public approach to education and training.

EU countries are responsible for their education and training systems, thus Union policies may support national actions and help address ***common challenges***, for example ageing

societies, skills deficits in the workforce, or global competition. The EU provides a forum for the exchange of best practices and the gathering and dissemination of information and statistics, as well as offering advice and support for policy reforms.

In the ***EU Education & Training 2020 Strategic Framework***, four common objectives have been identified:

- Making lifelong learning and mobility a reality;
- Improving the quality and efficiency of education and training;
- Promoting equity, social cohesion, and active citizenship;
- Enhancing creativity and innovation, including entrepreneurship, at all levels of education and training.

The ***Europe 2020 targets in education*** are to reduce the rate of early school leaving below 10% and to have at least 40% of 30 to 34-year-olds completing third-level education. The targets aim to reinforce educational improvements in the interests of enhancing employability and reducing poverty.

Technology and new modes of delivery can be part of the answer to the present problems in terms of both equity and excellence: by allowing people to learn anything anywhere; by letting universities concentrate on their areas of greatest added value; by offering a chance to rethink knowledge transfer at local, national, and regional levels; and by helping build capacity in emerging economies and developing parts of the world. (*Prats-Monné, 2015*)

Productivity, competitiveness, and innovation will have to grow, with fewer people being relied on. At the same time, in many Member States, education systems are still struggling to meet 21st-century expectations. Targeted policy action is needed to equip people with key transversal competences and to reduce low achievement in key basic competences.

The EU Education and Training Monitor 2014 identifies three main strands of policy levers that can help strengthen the impact of education and training systems: (i) improving the quality and inclusiveness of pre-primary and compulsory education by reaching out to the most disadvantaged; (ii) giving more attention to the teaching profession; and (iii) better exploiting the potential of innovative pedagogies and digital learning. Increasing the quality and relevance of qualifications and competences is a critical priority.

Facilitated by better transparency and recognition of learning outcomes, combining innovative pedagogies with an effective use of digital tools and content should boost education in terms of quality, equity, and efficiency. The existing European tools and initiatives are not wholly living up to their potential. *PIAAC (2014)* shows that education attainment levels do not correspond to the same level of learning outcomes across countries and it underlines the need to achieve a common understanding of quality, which is transparent across countries.

Among the medium-term strategic EU plans is the development of the ***European area of skills and qualifications***, which should support mobility for both work and education, employability, and quality education and the modernization of the education systems. The *Eurobarometer Study (2014)* reveals that a large majority of EU citizens (95%) consider that skills can be gained outside of formal education.

The European Commission's recent decision to move adult learning from DG Education and Culture to DG Employment raises questions about the Commission's commitment to lifelong learning. (*European Association for the Education of Adults EAEA, 2014*)

Writing about the Canadian higher education policy scenario, *Bates (2012)* summarises some relevant statements, of which most are valid in EU national environments as well. University online education is commonly constrained by the lack of national data and

strategic planning, of cross-jurisdictional collaboration, of convincing business models, and of economies of scale and resources. This limits the universities' ability to capitalize on the potential of digital technologies to improve uptake, quality, accessibility, return on investment, tactical innovation, and knowledge transfer. ***The ongoing strategic vacuum creates an environment that fosters weakness and duplication.***

Digital pedagogy

In the past decade, the environment of education has changed very quickly, with astonishing developments in the macro-factors of technology, globalization, and demography. Behind the various waves of reforms there has always been a change of paradigm. So far, education has mostly been following the "content delivery and assessment" model, with the main goal being the transmission of knowledge. Nowadays, technology is putting more and more tools in the learners' hands and education is becoming a service focussing on the learner, which provides much more freedom than earlier.

Eventually all "technology-enhanced learning" (e.g. integrating with mobile devices, augmented reality as a daily learning extension, context-driven learning, sensor-driven information, etc.) will become mere "learning". ICTs, meanwhile, avowedly support online learners in developing core 21st-century transversal-horizontal and soft skills such as communication, critical thinking, collaboration, time management, multi-tasking, maintaining a sense of well-being, and developing a sense of connectedness through the use of social media.

Research results on digital learners (*Garcia et al.*) reveal that although university students have a basic set of technological abilities, these do not necessarily translate into sophisticated skills in the use of other technologies or information literacy in general. Contradictions exist between the perception of technological proficiency and its use, which is much more restricted. Although access to and the use of ICT is widespread, the influence of teaching methodology is very decisive. For academic purposes, students seem to respond to the requirements of their courses, programmes, and institutions. There is a clear relationship between the students' perception of usefulness regarding ICT resources and the teachers' suggested uses of technologies. Despite dramatic increases in students' use of various technologies, their assumptions concerning how they might learn at university remain relatively static. These expectations appear to be influenced more by their prior experience of learning in formal situations rather than by their use of technology outside educational settings.

Starting in the second half of 2012, approaches towards ICT resources began, to some extent, to change. Centred on the movements of open educational resources (OERs) and massive open online courses (MOOCs), questions were raised on operational and management issues, querying the feasibility of the economic models of institutions. New stakeholder alliances emerged, supported by fresh social and economic demands and clusters of interests.

One unarguable general advantage of the OER/MOOC movements as far as the modernization of education is concerned is the increased awareness about and acceptance of ICT-enhanced, open, and flexible e-learning solutions, which, in many institutions, were previously not quite acknowledged as being integral parts of the learning process. Nowadays they have become impossible to ignore.

In the meantime, in the professional and academic think tanks, the systematic work, including the collection and analysis of data, mapping, and intelligent observations combined with justified analysis and validation, is slowly but substantially contributing to reaching a critical mass of reliable knowledge and relevant information about ICT use in education and training. Several elements are summing up, such as the experience on the technology side, the pedagogy dimension, the socio-economic aspects, institutional-structural issues, and the teachers' and students' behaviour, interests and characteristics. This process is helping to outline the scope of potential actions. A flexible formation of different clusters of scenarios can be observed, relying on the pool of experience, research results, and the analysis of case studies/practices – all increasingly making use of the powerful learning analytics tools.

According to *John Daniel (2015)*, ***new ways of doing assessments*** will have a huge impact on faculty members – there will be new ways of developing assessment processes; new ways of reviewing and marking assessments using machine intelligence and artificial intelligence; and new ways of connecting learning materials to assessment, permitting individualized learning and differentiated instruction.

Regarding the pedagogic challenges of the social web, we should note that the issue of advanced online course development, ***spontaneous knowledge management***, is emerging. The process of course development may frequently be too long and complex nowadays, whilst tutorial systems are also expensive, with the time of the instructor being the major cost. Students often use the social web very creatively and they build up wikis to replace LMS quite quickly. There is a demand for course design models that better control time and cost. This is linked to the desired paradigm change of using campuses in the right way with much stronger integration of online learning, applying various new sets of conditions.

It has been acknowledged that considerable ***differences exist between countries*** within the EU in several essential aspects. These may be related to socio-economic backgrounds and to differences in infrastructure development, government policies, the attitude and preparedness of the education and training sphere, the traditions regarding the openness of the sectors themselves, the use of the technology, the employment situation, the approach of stakeholders, and many other factors. General approaches and patterns at the basics, and similar pathways in elaboration and implementation may lead in different directions and to different places (both in policy and in ICT use).

An important interdisciplinary field connects the world of learning to the ***brain sciences*** and their anticipated ***contributions to the cognitive processes***. Better and deeper knowledge and responses to the question of how we actually learn (which is still a rather long-term endeavour) could greatly enhance the efficiency of ICT-supported education.

Notes on the open education movement

We can speak about the implications of transitions in approaches (openness), which may amount to changes in paradigm, not only for the use of ICT, but also for socio-economic-cultural processes and, in particular, business models.

An element inherent in the new MOOC platforms is their social component, with peer-to-peer interaction. This new dimension arises for two different reasons: (i) the explosion of the social dimension of the Web through Facebook and other means which transform the ways of acquiring and exchanging knowledge; and (ii) the necessity of replacing teacher-student

interaction with peer-to-peer interaction in order to facilitate mass teaching with tens of thousands of students following the same course.

To fulfil their goals, MOOCs require a pedagogical transformation: the students must learn by themselves while also becoming more active, exchanging knowledge and skills with their peers, and helping each other instead of passively listening to teachers (flipped learning). EPFL, in Lausanne, for instance, is progressively replacing its first-year theatre courses with MOOCs. At the same time, conventional e-learning modules will seldom fit into MOOCs and if their use is still necessary, they must be entirely rebuilt.

Two significant challenges concerning the role of MOOCs in higher education are prevalent. Firstly, the discussion on MOOCs has to date occurred mainly in the mainstream media and in professional publications. Although some peer-reviewed articles on MOOCs do currently exist, the amount of available research is generally limited. Secondly, the vast amount of research available in online and distance education portals has largely been ignored by the mainstream media and MOOC providers alike. Paying greater attention to what is already known about learning in online and virtual spaces, to how the role of educators and learners is transformed in these contexts, and to how social networks extend a learning network will enable mainstream MOOC providers and their partners to make evidence-based decisions in favour of educational reform. (*Siemens 2013*)

A slowing down of the open education movement can be observed from the second half of 2013, as evinced by the continued absence of coherent progress and processes, and the institutionalization of OERs and, in particular, MOOCs. Genuine national efforts for the support and recognition of such resources and courses are rare. Enthusiastic foresights, the extrapolation of certain – unquestionably valuable – changes to global scale, and the expected transformative impact dominate the information available. A similarity with the initial hype concerning ICT-enhanced and e-learning is to be found.

Disbelieving views even say that MOOCs represent little more than an elaborate and expensive marketing campaign in today's globally competitive student-acquisition market.

The COL-UNESCO report prepared for the World OER Congress in June 2012 admits that whilst there appears to be a great interest in OER all over the world, different regions face different obstacles in its adoption. Only a few explicit OER policies exist and there is apparently some confusion regarding an understanding of the concept and potential of OER; it is thus there is an ongoing need for further advocacy and information-sharing to motivate countries and institutions to harness OER.

MOOCs can provide a boost to meaningful research on human learning – very large samples are involved and the data collected from MOOCs and MOOC platforms is harvested and analyzed. MOOCs and OER can significantly contribute to higher education in a consistent, efficient, and economical way due to their ability to distribute knowledge throughout the world. As *Tait (2014)* emphasises, MOOCs have captured the imagination of not only many millions of learners, but also politicians, funding and philanthropic agencies, and even venture capitalists, in ways that open universities may have previously felt was solely their prerogative.

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REMÉNYI, Judit

ALWAYS-ON IN HIGHER EDUCATION - EMBEDDED USE OF MOBILE TECHNOLOGIES AT BME**Introduction**

Higher education is undergoing an economic and a pedagogical crisis: It is increasingly treated as an economic resource and commodity, its relevance is increasingly expressed in economic terms, and is in the focal point of numerous changes such as spending cuts, increasing tuition fees, heavier reliance on ICT to drastically change the student experience, and the need for complete renewal content, teaching and learning wise. In this hopefully great revival of learning, mobile technologies¹ (MT) could be given a central role.

The global problem of higher education

After centuries of unquestioned and unchanged patterns of university education, more and more education professionals, academics and students are crying for transformation. The students' general lack of satisfaction with higher education manifests itself among others in early school leaving, giving up higher education prematurely, transferring to other courses, poor academic performance; although, "success in higher education is vital for jobs, productivity and growth"². "Currently, too many students in the EU drop out before they complete their higher education degree. Students from a lower socio-economic background and other disadvantaged groups are the most likely to drop out", although it could be prevented in most cases. The case is not different at Budapest University of Technology and Economics (BME) either.

Obviously, there is not a single reason for early school leaving and poor academic performance, but the "business" is urging a revolutionary approach towards designing and delivering higher education courses and programmes relying on innovative delivery technologies and integrating students' performance boosting solutions. No doubt, cutting-edge delivery technologies without the support of massive pedagogical paradigm shift will not sustain the higher education status quo. T. Hixon, investor and Forbes contributor says "Higher education is now ground zero for disruption" and adds that "History teaches that productivity increase usually does happen, driven by innovation, especially in information businesses such as education. When it happens it is likely to be disruptive for institutions that believe it will not happen."³ "Blended courses, online learning, and MOOCs are moving at light speed compared to the typical university."⁴ Hailing the change will not be sufficient;

¹ The term mobile technologies is used in the paper to mean smart phones, iPads, tablet computers, but not laptops and notebooks.

² <http://www.nesetweb.eu/sites/default/files/HE%20Drop%20out%20AR%20Final.pdf>

³ <http://www.forbes.com/sites/toddhixon/2014/01/06/higher-education-is-now-ground-zero-for-disruption/>

⁴ Lucas, H.: Disrupting and Transforming the University. <http://cacm.acm.org/magazines/2014/10/178788-disrupting-and-transforming-the-university/fulltext>

we need to prepare for it by “reinventing”⁵ higher education, reconfiguring mainstream university education. The reinvention must result in a fundamentally altered learning experience. Class time should be devoted to more efficient ways of learning such as problem solving, discussion, interactive, cooperative activities, as for example in “flipped classes”.

The relationship of higher education and technology

Historically, higher education failed to have a technological core, but online learning meant a breakthrough in this respect. Online courses, blended learning, MOOCs⁶ have been disrupting higher education. “The established players, if history is any guide, will try to preserve their model as long as possible by making it a hybrid or a blended model where we teach in our classrooms and then we augment that with online resources—but without much doing, online learning will just supplant in classroom learning.”⁷

Initially, enthusiasm was running high, online courses were increasingly found to “provide efficient and timely access to learning materials”⁸ for students who are pushed into higher education by their parents still seeing extraordinary value in university education but needed more cost effective solutions. However, dissatisfaction with online learning is growing now as online courses are found to “deliver instructions without influencing students’ achievements”⁹.

So it might be stated that in spite of all our efforts, simply deploying state-of-the-art technology cannot do the trick. Although e-learning technologies were widely accepted as an effective addition to the traditional learning theory, the quality of teaching and learning practices has not been essentially improved.”¹⁰ So, we still need to squeeze the maximum number of students into lecture halls and exam-marking rosters¹¹ and are trying to do our best to keep the students motivated and provide them positive learning experiences. However, since Christensen coined the phrase *disruptive innovation*, an increasing number of those concerned with higher education have been discussing the disruptive effect of information and communication technologies on higher education. Its danger is even more obvious with the penetration rates of mobile technologies.

In the lack of a mobile tool specifically designed for education, in the following we focus on mobile devices¹² as a potential new “candidate” for altering university student experience. Mobile technologies can fulfill most of not all criteria of a disruptive innovation as they are products and services first taking root in simple applications at the bottom of the

⁵ Mehafy, G.: The Disruption of Higher Education.

<http://www.edtechmagazine.com/higher/article/2012/07/facing-changing-times-higher-education>

⁶ Lucas, H.: Disrupting and Transforming the University. <http://cacm.acm.org/magazines/2014/10/178788-disrupting-and-transforming-the-university/fulltext#T2>

⁷ Christensen, C.:The disruption of higher education. An interview by The Economist Intelligence Unit 2013.

<http://facultycommons.org/disruption-higher-education/>

⁸ Milner, E.:Students' Development in the Digital Age: Intellectual Freedom or Frivolity?

<http://www.ninjaessays.com/blog/students-development-in-the-digital-age-intellectual-freedom-or-frivolity/>

⁹ Milner, E.:Students' Development in the Digital Age: Intellectual Freedom or Frivolity?

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¹¹ <http://www.economist.com/blogs/freeexchange/2014/02/online-education>

¹² Mobile devices include smartphones, tablet PCs, and iPads, but not laptops or notebooks.

market and then moving up market and displacing established competitors¹³. “There is considerable interest in exploiting the almost universal appeal and abundance of these technologies for their educational use.”¹⁴ The educational capabilities of the new devices are driven by their technical capabilities. “These new capabilities inspire new practices which can lead to valuable outcomes, but, to date, application of theory to the use of these technologies for educational purposes is lacking.”¹⁵

In spite of the EU strategies, initiatives for mobile learning in formal education, “the practice of using mobile phones for education is still emergent”¹⁶ in the EU as national ministries of education seem to lack interest and awareness. Neither national guidelines, nor instructional materials are available for enthusiastic teachers, although mobile learning already began in the 1980s in Europe. Integrating mobile technologies into classroom education might be a solution for decreasing drop-out rates and increasing student performance.

The Hungarian situation

In 2014, the drop-out rate in Hungarian higher education was 35%.¹⁷ Varga, J. says that the drop-out rate in Hungarian higher education was 45% in 2010.¹⁸ It should be noted that high drop-out rates, switching to other university courses are international problems. “Students dropping out during just the first year of their degree are now running at an all-time high.”¹⁹

Faculty experience and education statistics²⁰ suggest that Generation Z students are not finding standard lecture courses interesting and motivating enough in Hungary either. While students drop out due to several reasons such as: academic factors, social factors, change of intention, motivation, and attitudes, organizational changes, and background changes²¹; the practice of extending university studies instead of completing the course in three years, which is a typical phenomenon in Hungarian higher education, can be more directly linked to academic factors. These students most likely have the least academic approach to their studies to get through examinations. In other words, we might say that their dissatisfaction and failure is more often than not due to the fact that we cannot provide them with effective and sustainable learning experiences. Furthermore, we do not seem to have a structured pedagogical approach to solve the problem or a viable alternative to the traditional teaching / learning system.

¹³ <http://www.claytonchristensen.com/key-concepts/#sthash.qdNB2fkn.dpuf>

¹⁴ Literature Review in Mobile Technologies and Learning

http://www2.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf

¹⁵ Literature Review in Mobile Technologies and Learning

http://www2.futurelab.org.uk/resources/documents/lit_reviews/Mobile_Review.pdf

¹⁶ Turning on Mobile Learning in Europe. Illustrative Initiatives and Policy Implications

¹⁷ <http://mno.hu/belfold/igy-lehet-megakadalyozni-a-lemorzsolodast-1259682>

¹⁸ Varga, J.: Mennyit ér a diploma a kétezres években Magyarországon ?

www.hier.iif.hu/hu/letoltes.php?fid=tartalomsor/1987

¹⁹ <http://www.dailymail.co.uk/news/article-2122591/More-fifth-university-students-fail-finish-degree.html>

²⁰ <http://observatory.org.hu/csokken-az-iskolai-lemorzsolodas-europaban-a-diplomasok-szama-pedig-no-magyarorszagon-nem-ilyen-jo-a-helyzet/>

²¹ Molnár, B.: A felsőoktatásban tapasztalható lemorzsolódás lehetséges okai

<http://www.slideshare.net/molnarbea/molnr-beta-lemorzsolodas-tanulmny>

The present MT use related situation at BME

The learning environment of higher education in Hungary can still be characterized by the one-size-fits-all traditional approach of top-down, often authoritative, one-to-one lecture driven content transfer. In other words, although digital technologies have been fast changing the way we learn, they do not change the way how students are taught at Hungarian universities. Despite the kind of conservative approach of numerous Budapest University of Technology and Economics (BME) faculty members, they observe that the majority of the students bring their own mobile devices and use them during classes even if that is often discouraged or even forbidden. That is, mobile media consumption is becoming mainstream at the University, although, as experience suggests the use of MT is less frequent for taking notes in the classroom than for other purposes. It implies a considerable pedagogical challenge for the faculty such as how to avoid the distracting effects of in-class digital media use or how to avoid the destructive effect of in-class social media use. Furthermore, it raises serious pedagogical issues such as that of balance between fun and hard work in learning, that of digital technologies related skill development instead of content provision, that of enabling collaborative learning and performance assessment instead of individualized solutions etc. There seems to be a relationship between the students' digital learning skills and the faculty's suggested use of digital technologies. Digital technology based new modes of learning are however not yet a reality at the University (and the situation is similar at other Hungarian universities as well).

Literature shows that educators worldwide "have considered harnessing these devices within and beyond the classroom" (Mueller et al. 2012) as they are transforming young people's learning habits and related expectations as well. Nevertheless, Hungarian higher educational institutions tend to be still failing to recognize the urgent demand for thorough changes. Although it is widely recognized – by faculty members also – that mobile technology has great potential for educational use, the following approach is still "mainstream":

"A university classroom. The instructor is reading aloud from a passage in the assigned work for the week. He looks up to find his students all deeply engrossed. Their rapture, alas, is not with him but with their laptop screens, their attention worlds away

Later that day, the professor fires off an email to his colleagues suggesting that laptops be banned from the classroom because of incidents like this."

(Davidson – Goldberg, 2010)

BME faculty members tend to have three strategies concerning the use of mobile technology, more or less similarly to their colleagues' strategies worldwide:

- Encouraging the use of MT. Having recognized the educational potentials of mobile technology and its prominence in the students' life, the followers of this strategy not only encourage the use, but also devise plans how to integrate the use of mobile technology into mainstream education to make incentive, collaborative, participatory learning reality. It should be noted that the encouraged use should be based on

preplanned pedagogical activities directing student attention on coursework related issues.

- Restricting the use of MT. Although it is a fact that students are far from paying full attention to the lectures, they are repeatedly engaged in some other activities such as googling, reading, etc. Digital technology is seen to compete with faculty for the students' attention thus is considered to be a major distracter. Frequently switching their attention back and forth—from listening to a lecture to using their MT for some non-class related activities can result in poor learning. - In this case the fact that students' behaviour and expectations have much changed is not properly taken into consideration.

As at present there is no commonly agreed theory of how to best use mobile devices to customize learning, faculty members will need to experiment with innovative solutions, appropriate for the nature of the course. It is obvious that it is a long way until we will be able to avoid the traps of misuse resulting in adverse effects.

- Tolerating the use of MT. Since most faculty members might belong to this category, for different reasons such as recognizing the educational potential of digital technology but not knowing how to harness it, or lacking the stamina to restrict the use, maybe not wanting to lose their popularity etc. It is necessary to persuade them to change their strategies and utilize MT for their own interest and for their students' benefit.

At the University there is no explicit policy on the in-class use of mobile technology except for phoning in-class and the use of MT in examinations, which is prohibited. Most faculty members tolerate their use, but it disturbs them, e.g. because of the distraction of attention. Once mobile technologies have reached the higher educational institutions, instead of restricting or tolerating their use, we should encourage and integrate them in the classrooms. However, it takes a long way to change approaches and strategies and use them confidently and efficiently. At present it seems that this kind of innovation and experimentation is not being fueled. Still, inspirations may come from the faculty's low satisfaction with their own pedagogical performance.

The research

The research, started in May 2014, is carried out at the Department of Technical Education, BME. The Department provides MA courses for engineer-teachers and economist-teachers and also numerous part-time postgraduate courses for teachers. Faculty members have gained invaluable first-hand experience of students' in-class MT use. Since the average "classroom size" varies from 12 to 50, it is possible to pay attention to the students' non-classwork related activities. Since the Department provides English language courses for foreign students, their patterns of MT use can be compared to those of Hungarian students. The observations and the urgent need for changing our strategies and methodologies have led us to design and start the research.

The goal of the research is to find out whether there are dominant patterns of in-class mobile technology use at BME, that is:

- What mobile devices students use,

- How often they tend to use MT in ninety-minute classes, that is whether they are light or heavy media users, and
- What purposes they use MT for.

International survey findings provide some information on the global situation; however, there are considerable differences among nations due to their characteristics and differences of cultures. The differences concern – among others – the way how often Hungarians tend to use their MT, what they use them for, their authority respect etc. What is evident is that Hungarians are “talkers”, tending to discuss anything in public aloud. Furthermore, Hungarian youngsters tend to obsessively use social media to have their own voice, to be “insiders” in a community and follow strong communication-related patterns. A recent Hungarian survey has found that 83% of the respondents (1,000 persons) use social sites. Another Hungarian survey reports that the number of Facebook users increased by half a million in a year and totaled in three millions. My experience suggests that Hungarian students respect authority more than foreign peers, as non-encouraged in-class use of MT in the first (few) week(s) of the course is not characteristic for Hungarian students.

The hypotheses of the research are:

- The great majority of the students at BME bring MT into class.
- Students at BME use their MT several times in class in a non-encouraged way.
- Students at BME use the MT for non-academic purposes more often than for academic purposes in class.
- The majority of the faculty members at BME do not encourage the in-class use of MT.

The stages of the research

The stages of the research are:

- Surveying Hungarian and international students doing different courses at the University by using a short questionnaire of close questions concerning the patterns of their MT use,
- Interviewing teachers about their readiness to integrate mobile technology into their classes,
- Designing models of integrating MT into lectures taking into consideration dominant educational cultures, specific course/programme characteristics, teacher preferences etc.,
- Analysis of the results and producing recommendations concerning the optimum in-class use of MT.

A paper based survey was chosen since it was essential for the students to complete the questionnaire immediately at the end of the ninety-minute lecture, when they may not have forgotten how they had used their devices.

Preliminary results of the survey

The survey of students started in May 2014 and is still in progress. The first results suggest that:

- The use of smart phones can be considered general, while i-Pads, e-Readers, tablets are used sporadically. Foreign students seem to be better equipped with MT than their Hungarian peers. The enhanced affordability will certainly increase the rate, consequently we need to prepare for the general use.
- Almost as many respondents use mobile technology (MT) for academic purposes as for non-academic purposes in class. Those who report using MT for academic purposes use it for checking online dictionaries (foreign students, Hungarian students doing a course in foreign language or studying foreign language), checking course related information (such as course requirements, deadlines etc.), accessing outside resources, taking notes, taking photos and recording. However, almost half of the respondents report using MT for reading and writing text messages and using social networking websites. The increasing volume and the improving quality of online information may further encourage the non-encouraged in-class use. At the same time social changes might further increase the importance of “staying connected to a social site”. Consequently the use of MT for non-academic purposes will also increase.
- The respondents use MT at least 1-3 times during a ninety-minute class, but almost as many respondents report that they use them 4-8 times. MT frequency of use indicators will obviously not decrease or stagnate, so we either can devise “checking-in”, “sharing location” related pedagogical activities or need to get used to this kind of distraction.
- A great majority of the respondents report that they think MT will change education. This should be well understood and become common goal of faculty members. However, it should preferably be supported by findings on in-class use patterns related surveys and systematic planning and design.

In a similar survey, Kinash found that “mobile phones appear to be used mainly for non-academic (off task) activities with students reporting that 80% of mobile use was dedicated to social networking, 75% for web browsing and 68% for email”. (Kinash et al., 2011) It is obvious that mobile devices polarize student activity in any learning environment, some only use MT for class-related purposes, while at least as many students use MT for non-class related activities as well.

Conclusion

As the preliminary results show that the majority of the students bring their own MT devices and use them in class, it is obviously necessary to experiment with innovative approaches to integrate the use into traditional lectures as well. No doubt – as surveys and empirical experience suggest – the in-class use of mobile devices in lectures may increase interactivity, and the different ways of in-class use of mobile devices allow for a personalized educational experience. Furthermore, the encouraged in-class use of MT – leading the students to reach sooner digital media consumption saturation point (global survey findings suggest that our digital media consumption is increasing) – can have a positive effect on student attention, consequently on learning. The use of MD in a university environment can be an added value and an incentive as well. The mode and frequency of the use can be defined after the survey has been finished and the results analysed, since the mainstream patterns of non-encouraged in-class usage should be considered when designing tomorrow’s university education at BME.

Knowing the high penetration of mobile devices on the BME campus, we argue that mobile technologies should not be ignored as part of the learning environment and experience. There are two ways of integrating MD into university instruction: either students will work out for themselves how to use them for their learning, or faculty by understanding and accepting the limitations of mobile technologies and studying whether mobile applications are suitable for a given purpose, make sensible decisions about how to use them²².

The use of mobile devices at universities can be beneficial both for students and faculty. On the one hand it can enable students to:

- stay productive in lectures,
- access the learning management system of the university and access course-related information,
- take notes and structure and organize them and later restructure them,
- share notes and use them anytime and anywhere,
- have access to faculty provided class materials,
- have access to extra content,
- view visual images,
- look up cases, statutes,
- use online dictionaries,
- use electronic learning resources.

On the other hand it can enable faculty to:

- transferring information,
- directly support the learning process,
- divide lecture-type classes into several micro learning units and provide feedback to each,
- intensively engage students and keep them involved,
- personalize the learning environment and the learning path,
- encourage collaborative learning,
- (more or less) satisfy students' need for media consumption,
- prevent students' multitasking,
- keep students off of social media sites,
- (radically) decrease MT related distraction to others.

We argue that pedagogical innovation is being pushed by new mobile technologies extending the boundaries of teaching and learning. Consequently, mainstream patterns and modes of university education should be rethought and development strategies of MT integration should be formulated, and methodologies should be developed taking into consideration increasingly diverse learner backgrounds, in terms of prior knowledge, learning needs, learning strategies, dominant media consumption customs etc. This way our efforts might result in a quality twenty-first century higher education model.

²² Armatas, Ch., Holt, D., and Rice, M.: Balancing the possibilities for mobile technologies in higher education

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THE POTENTIAL BENEFITS OF ANALYSING GEOGRAPHICAL NETWORKS IN ADULT EDUCATION

Networks

The importance of various relationships has been proven in practice several times. We can find actual examples in our own lives – when considering the events of a particular day, we will see that those activities of ours which were successful were related to our participation in numerous networks of various kinds. We may start the list with the transport network that helps us get to work and also mention the communications network that facilitates the location and redistribution of information, or our very own social network where our friends and acquaintances supply us with news. In the meantime, larger networks which are hidden from the eye, such as the economy, nature, or culture are also at work.

Living is apparently impossible without networks, yet we pay little attention to them and consider them only at the level of everyday practice. We could certainly improve our roles and the efficiency of our actions within networks if we knew more about them and learnt about their operational principles.

This topic is considered in the books of Albert-László Barabási and Péter Csermely, which introduce the topic in a popular form to the wider public.

For a long time, networks were modelled using Pál Erdős and Alfréd Rényi's theory about random graphs, where the connections between nodes are completely arbitrary [1, 2]. Barabási and his colleagues, however, discovered that certain networks do not follow this random scheme at all. Their first subject was the World Wide Web, where they examined the system of home pages and the system of hyperlinks. In this case, degree distribution follows a particular power function, also known as scale independent distribution. While attempting to explain the organizing principles of scale independent networks, the researchers discovered several specific internal characteristics belonging to these complex systems.

The experiment of Stanley Milgram (1967) [3] highlighted the phenomenon of "small worlds". This means that in large, complex systems with numerous components, such as a society populated by humans, the Internet with its home pages, or a living organism composed of cells, the length of the path between two points, no matter how distant they are otherwise, is surprisingly short. In Milgram's experiment, the number of links needed to connect two people who did not know each other was on average four to six. On the World Wide Web, we may navigate from every single page to any other in an average of nineteen clicks.

When developing the rules for scale independent network models, Barabási and his associates discovered, among other things, that unlike in the classic random graph model, new elements are continuously added to the original complex system. When this happens, the new elements are more likely to be linked to nodes that have a greater than average number of connections to others. This principle is termed "the rich get richer" and real life proves the theory here, as people are keener to befriend those who are popular and to visit places that are well-frequented, etc.

When examining the behaviour of the Internet, it was also established that the willingness

to connect is not defined by the time a node joins the system but its “fitness” for connection from the perspective of the elements to be linked to it. This is known as “the winner takes all” and a good example of it is the late rise but extreme success of Google in comparison with other search engines. This principle explains how certain nodes in a network may have an extremely high connectedness.

Barabási and his team conducted an interesting experiment with scale independent networks. They randomly removed nodes from a network and then examined the coherence of what remained. They found that scale independent networks are resistant to random failures. However, as the system is not homogenous, targeted attacks on selected nodes with a high connectedness results in the disintegration of the entire network.

Nodes with a central function also play a role in another case. Though Barabási and his colleagues used Internet viruses as illustrations, the spread of other phenomena such as advertisements is also a good example (Facebook wishes to take steps against the unlimited circulation of fake news in the social network [4]). If we wish to disseminate something in the system, we should start at the central nodes. The same applies to preventing the circulation of a piece of information.

It is important to be familiar with the characteristics of scale independent networks – for example, their strengths, weaknesses, and behaviour – as networks with more or less identical structures will be similar, regardless of the differences in their content. Knowing the behaviour of one system, we may predict that of another.

Network characteristics

When we are familiar with the characteristics of scale independent networks, we may decide whether the network we are studying belongs to this category or not.

Fig. 1 shows a random network that complies with the Erdős-Rényi principles. Visualizing only a few nodes and edges already results in a confusing pattern where the groups of nodes with a high or low connectedness are difficult to identify, if their identification is possible at all.

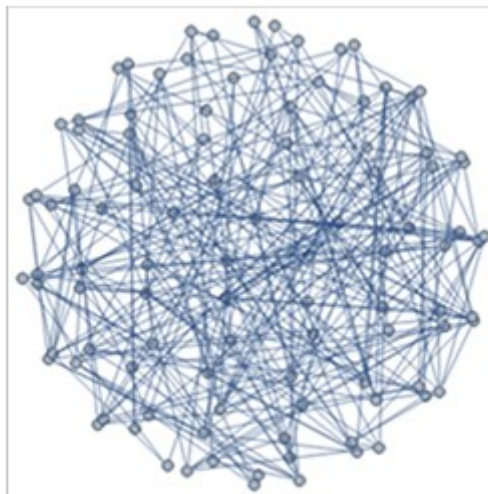


Fig. 1. Random network

Histograms (see Fig. 2) provide much more information. The degree distribution of the examined graphs may be read on the horizontal axis of the diagram (from left to right), while the vertical axis gives the number of the relevant nodes. In Fig. 2 we can see, for example, that in the examined network there are five nodes with 3 degrees (neighbours) and nineteen nodes with 7 degrees. It is also important to consider the shape of the histogram. In this particular case we can see that most nodes are connected to nineteen edges in the system and there is no single node with an extremely high number of connections.

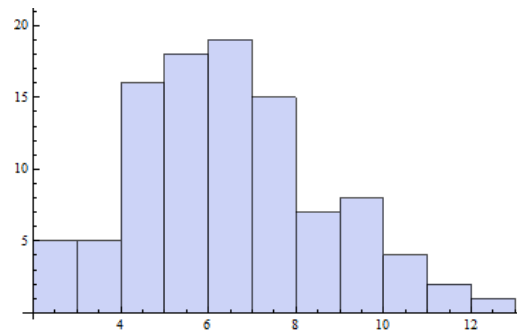


Fig. 2. Degree distribution of a random network

The graph of a network in the Barabási model (Fig. 3) appears to be quite similar to that in Fig. 1. However, its histogram (Fig. 4) indicates a radically different pattern of behaviour.

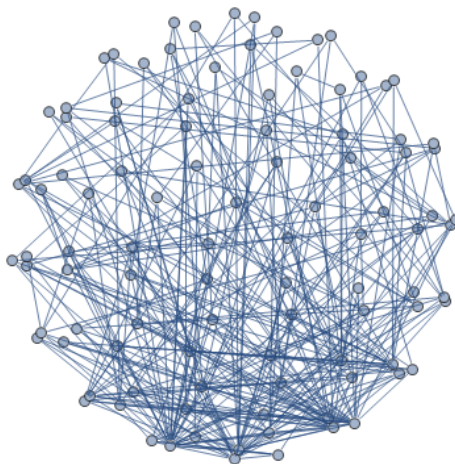


Fig. 3. Scale independent network

Most nodes have only a low connectedness (five or fewer connections) and the number of highly connected nodes decreases rapidly. However, moving along the horizontal axis to the right, we can still find one or two nodes with very high degrees.

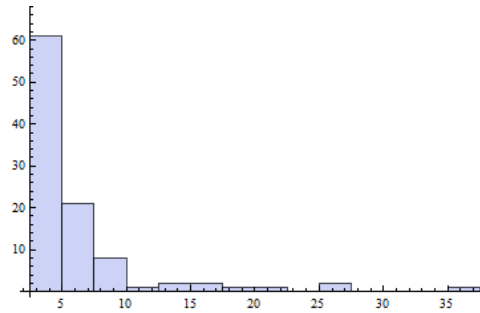


Fig. 4. Degree distribution of a scale independent network

Examining Geographical Networks

In education, networks are mostly examined at the level of sociometric surveys, although the assessment of other systems could also yield important results. From the various levels presented in education, we selected a geographical network as the subject of our examination.

The training programme for public education managers of the Budapest University of Technology and Economics is an adult education course that has its centre in Budapest while offering opportunities for consultation in several other towns in Hungary. The network is built up of geographical locations (nodes) while connections (edges) are represented by pathways that start from Budapest and provide for the spreading of educational content and pedagogy.

Now that we have defined our geographical network, let's see how it looks. Fig. 5 shows the settlements in Hungary where the students live and work, i.e. the locations where the content of the training course will eventually arrive, travelling in the minds of the students in the form of thoughts and elements of knowledge.

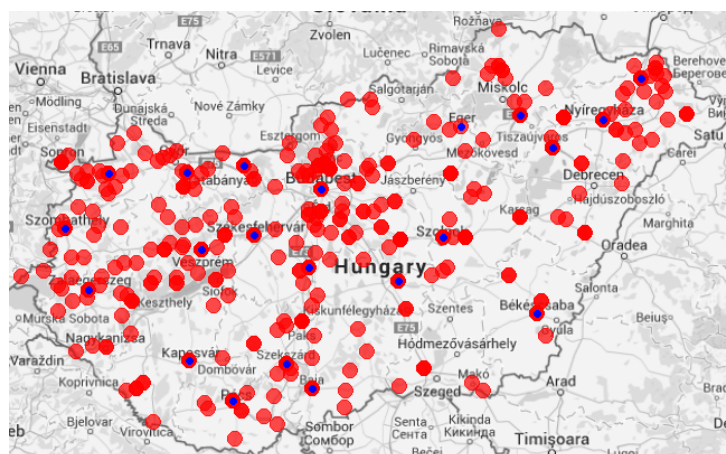


Fig. 5. Home towns of students (red)
and consultation centres (blue)

Fig. 6 illustrates the two levels of the geographical network. Light blue indicates the connections between consultation centres, while dark blue signifies the links between students and consultation centres. In the figure, we can see the locations visited by the students as well as the spread of “knowledge packages” throughout the country, starting from the Budapest centre.

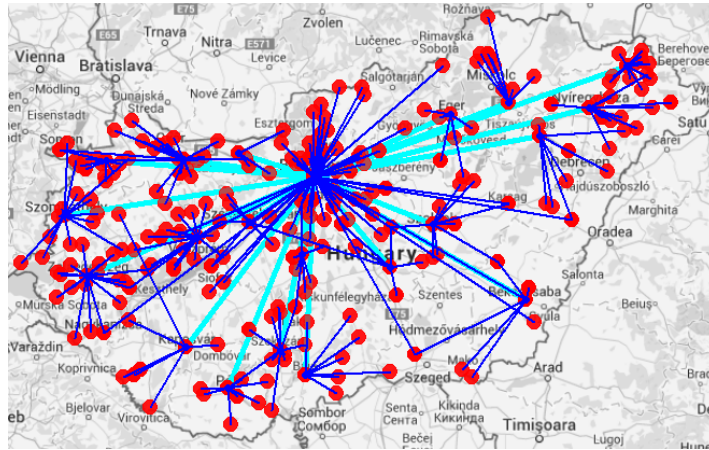


Fig. 6. Levels of geographical networks

In Fig. 7, we attempt to visualize the distances that would be travelled by students if the content of the programme was only available in Budapest. The average distance to be travelled by a student in such a scenario would be 106.8 km; when local consultation centres are also used, the distance is only 19.7 km. Calculating with an average fuel price of HUF 400/l and a consumption of 8 litres per 100 km, a student would spend HUF 3420 on travelling in the first scenario and HUF 630 in the second. If we assume an average speed of 60 km/h, travelling would take an average of 1.8 hours when only the Budapest centre was available for training and 0.3 hours in the case of local centres. Extreme values do stand out of course; for example in the first scenario a student living particularly far from Budapest would be required to travel 265 km (4.4 hours) to participate on the course. Providing for the comfort of students is not a *l'art pour l'art* initiative. Students who need to travel less can focus more on their studies. We should also consider the fact that decentralized education may be of higher quality, as participants not burdened by the strains of travelling can be loaded with more information.

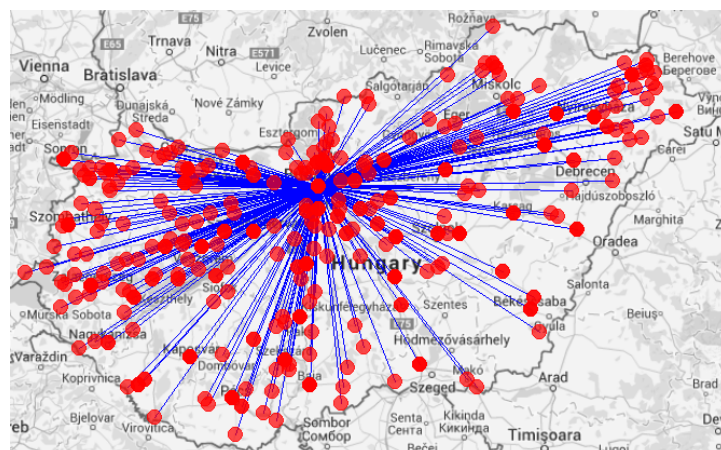


Fig. 7. Centralized network with its centre in Budapest

The mathematical analysis of this geographical network provides even more details. Fig. 8 shows the examined network as a graph. The average degree has been established as 2.15. The structure of the network can be clearly distinguished: the centre (Budapest) is connected to each local consultation centre and also serves as one itself, while additionally being connected to the home towns of the students. Local consultation centres are also highly connected. The home towns of the students, on the other hand, rarely have more than one connection (the reason for this is that students from the same town could choose from several local consultation centres and travel to these places along different routes).

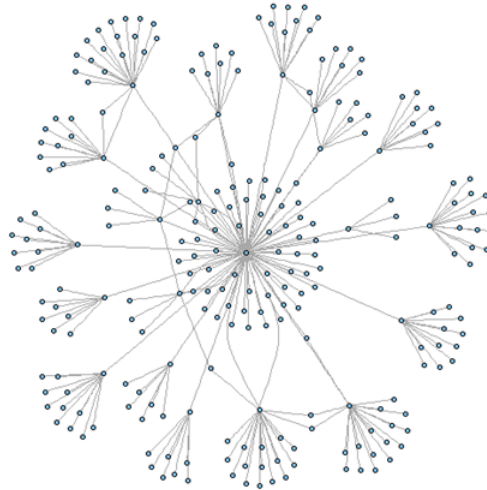


Fig. 8. Geographical network visualised as a graph

Degree distribution is given by the histogram in Fig. 9. Note the unique shape of the histogram.

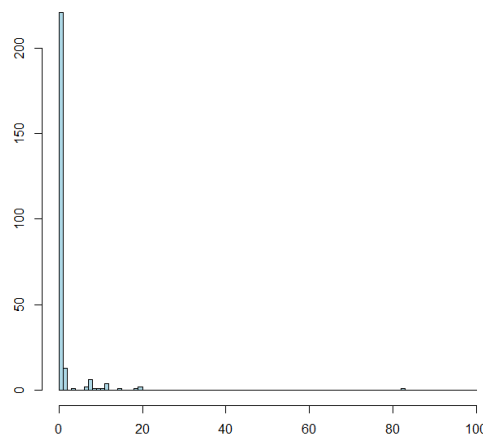


Fig. 9. Degree distribution of the geographical network

In addition to the central node with its eighty-three connections, the network includes numerous (about 221) nodes with one connection only.

We generated an Erdős-Rényi random graph with 245 nodes and 275 edges. This graph has the same number of nodes and edges as the examined geographical network, but differs from it regarding its internal building forces. We attempted to highlight this difference by mathematical analysis.

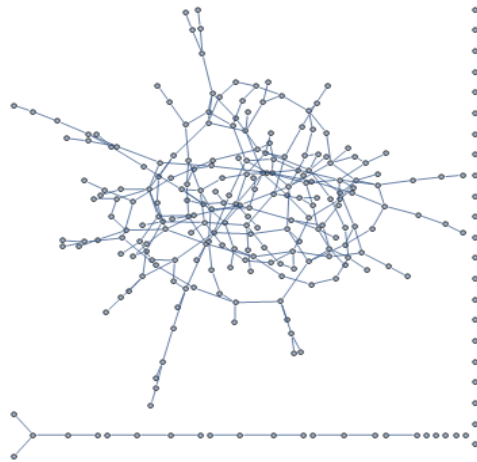


Fig. 10. Random graph with 254 nodes and 275 edges

The average degree of the nodes of the graph in Fig. 10 is 2.16. As can be clearly seen when examining the largest coherent section with an average degree of 2.5, this graph also includes unconnected nodes. Fig. 11 shows the degree distribution of the nodes of the original random graph. As illustrated by the figure, the majority of nodes are connected to three others, while a relatively small number of nodes have very few or very many connections.

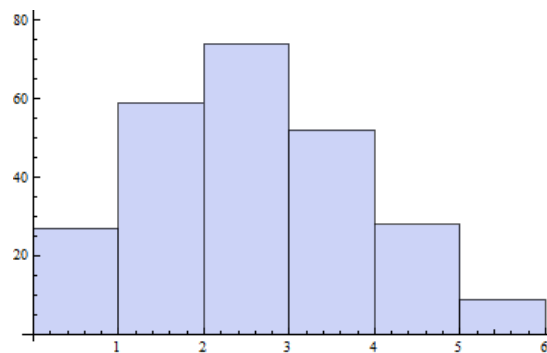


Fig. 11. Degree distribution of the random graph

Fig. 12 shows a network which is quite similar to the examined geographical network, but which is scale independent. As we can see in Fig. 13, there is a node on the right-hand side of the distribution curve with a degree of 25, while the number of nodes with only one degree is 170. This graph is entirely coherent, with an average degree of 1.99.

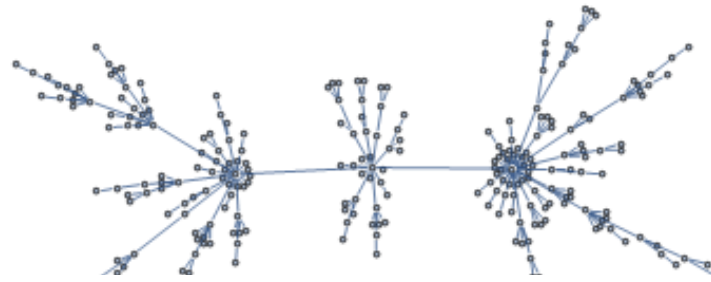


Fig. 12. Scale independent network with 254 nodes and 253 edges

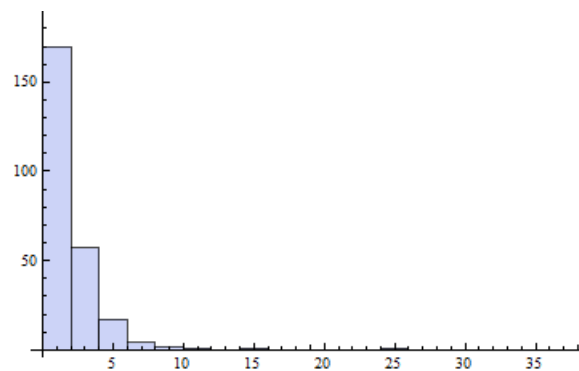


Fig. 13. Degree distribution of the nodes of the scale independent network

The histogram of the geographical network is similar in shape to the Barabási scale independent system. In addition to the large number of nodes with only a few connections, there are also some nodes with high degree values (though only one or two) featuring large empty sections between them when moving along the horizontal axis to the right, while the histogram of the random graph does not have such “remote sections”.

In our case, this means that the characteristics of the network resemble those of a scale independent system. The presence of a central node (Budapest) also indicates this. Although the structure of the examined geographical network is not overly complex, it has a large number of elements. It is not uncommon in training practice that a few consultation locations cease to operate during the programme; despite this, the system itself will remain functional. In this respect, it resembles the robustness of scale independent networks. The central node, however, plays an essential role. If it is removed, the network disintegrates – which is also a trait of scale independent systems.

Future prospects

We examined an existing, functional education system, identifying the related geographical network. We found the system to be very similar to scale independent networks, showing both their positive characteristics and their drawbacks. The current geographical structure of the aforementioned training programme for adult education managers has been developed over a long period of time, although this type of geographical outsourcing was applied from its inception. Such decentralized operation has quantifiable advantages. Students’ travelling costs are

reduced, as they are able to visit local centres instead of having to travel to Budapest. Another, indirect, benefit of the system is that participants are more relaxed and receptive during the consultations than they would be if the entire training programme took place in Budapest. In the latter case, the organizers would also face a serious challenge, as it would be virtually impossible to find a venue that could host several thousand people and also because communication with so many participants would be an extremely difficult task. Analysing networks in the fields of both education and adult education has great potentials. Interesting results are to be expected from the analysis of other network components of education (infometrics, sociometrics, etc.), too.

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NYÍRI, Kristóf

INTRODUCING THE PAPERS IN THIS SECTION

With its unprecedented wealth of images, animations and videos, the digital-networked world poses a completely new challenge to the entire educational system, in particular, also, to higher education. In what sense can we speak of a visual liberation, a visual home-coming? How should visual contents be combined with traditional textual ones, to what extent are images autonomous carriers of meaning, what does a logic of images – still or moving – amount to, how can display-sized multimedia documents be structured, and integrated into a networked system? How can a conservative balance be created between the classical world of texts and the new world of images, what does the responsibility of intellectuals mean in an age of transient texts? At the same time how can pictorial communication alleviate the depersonalizing effects of digitally mediated connections?

It is in this context of issues and questions the Visual Learning Lab (VLL), at the Department of Technical Education, Budapest University of Technology and Economics, pursues its inquiries. On Nov. 14–15, 2014, the VLL held its 5th international conference: VISUAL LEARNING: PICTURES – PARABLES – PARADOXES. In the call for abstracts for the conference we have called attention to a particular set of problems bedeviling cutting-edge educational theory and practice at the very present juncture: “With the linguistic turn having become past history, and the iconic turn no doubt victorious, second thoughts are gradually arising: Is that victory not a much too complete one? Are philosophers, cognitive scientists, media theorists, and educationalists in particular, sufficiently aware of the dangers the neglect of a polished verbal logic and of verbal culture imply? Maintaining the right equilibrium between the pictorial and the verbal has once more become a burning issue.” While this was, then, the main perspective we formulated, we listed, too, a much broader set of possible topics, such as: educational theory and visual learning; resemblance, representation, reality; image and language; images and media theory; visual rhetoric; pictorial meaning; pictorial communication; visual imagery; visual intelligence; the visual mind; the image problem in the history of philosophy; visual argument; scientific visualization; visualization and higher education; images in the network age.

The conference submissions underwent a blind peer-review process. Eventually, forty-four researchers from twelve countries presented their scientific results. The edited versions of some twenty of the talks will be published in the 5th volume of our VISUAL LEARNING series, under the title *Beyond Words: Pictures, Parables, Paradoxes*, to appear by September 2015. And four of the talks have been selected for publication in the present English issue of *Opus & Educatio*.

The first of these, by András Benedek, sets the stage by sketching the history of the VLL project – a project he has been, let us say here, a main initiator and organizer of. Benedek then goes on to discuss that what has been our main issue at the conference, focussing on the intriguingly unstable ratio of the verbal and the pictorial when examining the gamut of successful, or indeed unsuccessful, educational messages. A felicitous metaphor Benedek introduces – or is it more than a metaphor? – is that of the mathematical notion of the *parabola*, a metaphor suggesting the endeavour of keeping *equal distance* from a point and a line, just as perhaps ancient parables strove to keep equal distance between points of views expressed in an image on the one hand, and textual lines inspired by those points of

views on the other. At one stage, Benedek uses another metaphor – or is it more than a metaphor? – to refer to the intertwining of the pictorial and the verbal: the metaphor of *comics*. And precisely comics is the explicit and central theme of the highly interesting paper by Krisztina Szabó. She argues that “reading digital texts containing visual elements is a non-linear kind of reading which is indeed very much like comic reading”. Szabó stresses that “visual elements which appear on digital interfaces have strong effects and influence on our cognitive processes, especially on reading and text comprehension”. In pursuing her argument, Szabó spells out in detail what the notion of a “visual element” actually covers. She considers visual elements to be “pictures, graphics, and any kind of design elements of a website, word clouds and gifs. The interactive advertisements and the graphical elements of a Prezi or a Power Point presentation are also visual elements”. *Prezi*, a popular online presentation tool with essentially Hungarian roots, is the topic of Anna Szlávi’s paper “Metaphors Matter: The Analysis of Prezi in Search of Visual-Verbal Metaphors”. There is, as Szlávi shows in her fascinating analysis, more to Prezi than meets the eye. Prezi’s founding philosophy is clearly not independent of cognitive science in general, and conceptual metaphor theory in particular. However, Prezi’s users are quite generally entirely unaware of, and certainly do not exploit, this dependence. Similarly unaware are, as Kristóf Fenyvesi and Raine Koskimaa explain in their paper, the users of some very specific *digital games* of the complicated metaphysics underlying their playful, but often also painful, employment of “impossible figures”, figures optically well-structured, with a design however actually not yielding to be logically figured out. Fenyvesi, Koskimaa, and their associates have been for quite some time now conducting impressive experiments showing how dealing with, trying to understand, illusive images is conducive to mathematics education. Mathematics is, for most people, difficult; “impossible figures” become, to any onlooker, difficult on second look; the two fields, appropriately joined, might become a joyous playing field.

Visual learning might have been seen to be an easy playing field until recently, even if regarded with suspicion from the point of view of mainstream educational theory. The suspicion is still there, we feel; but the playing field has become an actually more difficult, because better understood, domain for innovative pedagogy. Game over? On the contrary, it just begins.

BENEDEK, András

MORE VISUAL CONTENT INTO VOCATIONAL EDUCATION

Introduction – a Chance for a Synthesis

Quo Vadis Visual Learning? This question probably preoccupies the initiators and organizers of the Visual Learning Lab (VLL), who may approach the question from various aspects, yet in the same way. The VLL monthly research seminars were launched in 2009. As an excellent illustration of the multidisciplinary attitude, they touched on a great variety of topics, and soon led to a series of yearly international conferences, at which by 2014 altogether some 150–200 participants have become “regulars”. Our professional diversification is obvious, as illustrated by the VLL homepage <http://vll.mpt.bme.hu>. The undisputed complexity of the topic is a valid argument. As we were getting along with the story, the over 30 thematic research seminar discussions revealed an exciting pageant where subjective dispositions are supported by disciplinary motives. Budapest University of Technology and Economics (BME), as a classic institution of higher education, added its conservatism, strictly in the positive sense, as a feature related to both technical development and training and education processes. At one of our very first research seminar meetings the topic was “Images, Science, and Higher Education”, the discussion referring to books by Martin Kemp¹ and James Elkins². Soon, too, we succeeded in establishing working connections to a similar – earlier – UK initiative.³ Initially the Budapest VLL project perhaps seemed to be nothing more than an example of a small country making a spiritual effort that might even gain some recognition due to its global context; however, the annual international conferences, with the first one organized in 2010, created a new, even more essential scientific debate forum the results of which to date have been published in four volumes of the VISUAL LEARNING series.⁴ Acknowledged international experts who are able to demonstrate the multidisciplinary aspect of the subject in a wider context shared their thoughts and their newest achievements in theoretical and empirical research related to visual tools, directly with the participants of the conferences and indirectly with the broad professional public. An excellent example of this is our long-term collaboration with James E. Katz, an expert of world renown on the social science of mobile communications.⁵

¹ Martin Kemp, *Visualizations: The Nature Book of Art and Science*, Oxford: Oxford University Press, 2000.

² James Elkins (ed.), *Visual Practices Across the University*, München: Wilhelm Fink, 2007.

³ Cf. <http://www.nottingham.ac.uk/visuallearninglab/visuallearninglab.aspx>, *Showcase of Innovations in Visual Learning*. Nottingham University, 2010.

⁴ András Benedek and Kristóf Nyíri (eds.), *Images in Language: Metaphors and Metamorphoses* (series VISUAL LEARNING, vol. 1), Frankfurt/M.: Peter Lang, 2011, 205 pp. – András Benedek and Kristóf Nyíri (eds.), *The Iconic Turn in Education* (series VISUAL LEARNING, vol. 2), Frankfurt/M.: Peter Lang, 2012, 164 pp. – András Benedek and Kristóf Nyíri (eds.), *How to Do Things with Pictures* (series VISUAL LEARNING, vol. 3), Frankfurt/M.: Peter Lang, 2013, 224 pp. – András Benedek and Kristóf Nyíri (eds.), *The Power of the Image: Emotion, Expression, Explanation* (series VISUAL LEARNING, vol. 4), Frankfurt/M.: Peter Lang, 2014, 287 pp.

⁵ His latest edited book is the volume *Living Inside Mobile Social Information*, Division of Emerging Media Studies, College of Communication, Boston University, <http://us8.list-manage.com/track/click?u=2fe8f203b1eb854924a38e031&id=a91e508b8c&e=94aa0f2163>.

Visual Learning – Paradox or Contradiction?

This paper focusses on a contradiction related to the subject both in an institutional and a broader context and considers a critical element of this process rightfully perceived as progressive. The contradiction roots in the fact that while several disciplines acknowledge the role of visual tools in human communication and it is strongly promoted these days by mobile ICT tools that facilitate visual communication in space and time, this progressive approach could not yet penetrate the theory and practice of education and training.

Also referring to the title of the conference, this paradox of the development of visual learning may be perceived as a parabolic situation whose theoretical and partially practical analysis is particularly important, with special regard to the aspects above. Obviously, we do not have to convince those directly involved in visual learning that images have always had a significant role in human communication. Around the turn of the millennium what we might regard as a kind of visual homecoming had an increasingly strong impact on daily communication, and through that on education,⁶ institutionalized education in particular. The mass penetration of ICT tools brought a significant spontaneity into learning processes; no wonder it was very hard to make it compatible with the visual contents of curricula designed and objectivized in algorithms that had been in turn designed in the framework of the national curricula. The visual contents in traditional textbooks and online curricula, the latter also serving as an illustration of the actual status of the technical infrastructure, have not changed much in the past decades.

A reason behind this phenomenon is conservatism, considered an essential feature of education and knowledge transfer in general that prefers stable, fixed knowledge elements and has had validation, authority and professionalization in the center of its paradigm for centuries, hence being unable to provide the necessary space for visual learning.

Determination of the Issue in the Context of Cultural History

Visual learning was already known in ancient societies and not only as a tool for daily communication or daily knowledge transfer. Parables created a virtual double dimension, where short, figurative speeches could convey the meaning of an idea by using a picture or metaphor of ordinary life. In European cultural history, the Greek '*parabolé*' refers to this. Thus, the word "parable" may be used as an umbrella term that includes every relevant thing from simple comparison to artistically elaborated allegories.

Teaching as a term also has a Biblical interpretation. In particular in the Jewish-Christian tradition, teaching by means of *parables* used to be immensely popular and the method always generated attention both in Jewish and non-Jewish audiences. Jesus was particularly keen on teaching people this way. Good examples are the Parable of the Lost Son or the Parable of the Good Samaritan where messages are conveyed by means of detailed stories. Obviously, these metaphorical stories were used on purpose, especially as Jesus had to acquit himself from the charge of performing his miracles by the help of Beelzebub. This is how parables had become a consciously applied method of teaching for Jesus, who had to

⁶ Cf. e.g. Kristóf Nyíri, "Images in Conservative Education", in Nyíri, *Meaning and Motoricity: Essays on Image and Time*, Frankfurt/M.: Peter Lang, 2014.

withstand the increasing hatred of the Pharisees who hoped to catch him by something he said so that they could arrest him.

We also have to mention here that 'parabola', i.e. the mathematical interpretation of the word parable and the relevant graphical representations are as old as the stories referred above. The similarity between the mathematical representations and the general features of the communication typical for learning situations is believed not to be incidental.⁷

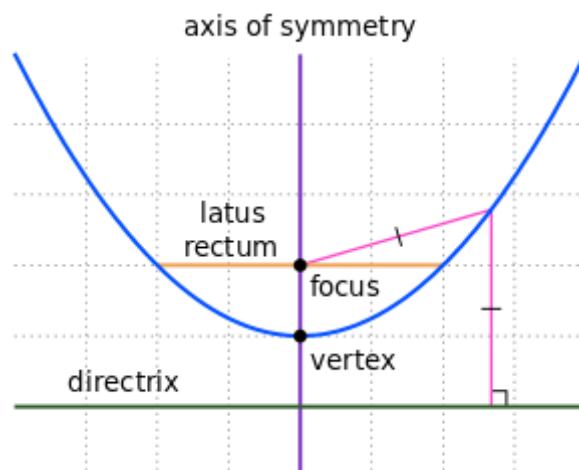


Figure 1

It is important to note before further elaborating the idea that a parabola may be positioned in a Cartesian coordinate plane in a way that its axis of symmetry is represented by the y axis (the axis of ordinates) and its focus is the origo, where the axes of the coordinate system intersect. This construction allows the analysis of correlations where the amount of verbal information is plotted on the horizontal axis and that of visual information on the vertical one.

To provide an illustration for the thoughts to follow, let's take a look at the simplest quadratic function, $f(x)=x^2$ and the relevant equation. The equation $y=x^2$ does not only determine the form of the curve, but also refers to the nature and ratio of verbal and visual information provided in the curriculum for a particular learning content (hereinafter referred to as T , after the Hungarian for knowledge element). The amount of verbal information is plotted on the x axis while that of visual information on the y axis. In our thought experiment, we presume that increasing the amount of verbal information in a linear fashion results in a significant, quadratic increase in the amount of visual information for the same knowledge element (T). This presumption may be considered realistic, knowing the usual text to pictures ratio in books, etc. On the other hand, it also indicates that a significant (4-fold or even 16-fold) increase in the volume of visual information only corresponds to a 2-fold or 4-fold increase in that of verbal information for any given knowledge element on the parabola.

This example emphasizes that according to the equation of the parabola, for the same "directrix sections" (in our example, amounts of verbal information related to a given knowledge element) significantly more visual information is allocated (in our example, the increase is quadratic). If these ratios are altered significantly, the resulting curriculum will be predominantly verbal or predominantly visual. In both cases, acquiring knowledge will

⁷ Cf. <http://en.wikipedia.org/wiki/Parabola> (see Figure 1).

probably be severely hindered. We have to note here, that in our thought experiment the ratio of verbal and visual information for a given curriculum is only based on estimations. Though these ratios may appear to be perceivable, calculating the actual functions requires empirical studies.

The Background of this Research

The creation of open curricula with rich visual contents has become an important direction for the international development of contents and didactics; the process is typically characterized by the constructive contribution by learners. Another typical feature is broad scale public access that is facilitated by modern, interactive on-line interfaces. This specific field is dominated by initiatives in tertiary education (MOOC – Massive Open On-line Courses); however, the significant number of learners in vocational education, the wide range of professions they represent and the fact that the age of those attending such courses has been steadily increasing urge the adaptation of these methods in vocational education as well.

In Hungary, the legislation on public education and vocational training was transformed between 2011 and 2013 and the education of teachers took a new turn. A general expectation regarding the education of teachers is that qualified teachers should be well prepared and able to cope with the following tasks:

- tasks of public education as defined by the National Curriculum according to development fields and educational objectives; transfer of the values and contents of education; knowledge building; development of core competencies and making use of them;
- providing teaching services in public education institutions in accordance with their professional qualifications, in the phases of formal education defined by the Act on Public Education and in the framework of approved curricula based on the National Curriculum; providing teaching services in non-formal education and adult education; performing educational activities in the employing institution;
- creative participation in educational development programs relying on their knowledge and experience.

Thus, our research on didactics essentially focuses on the differentiated control of the work of vocational teachers in class and the application of efficient educational methods and processes. From the aspect of this research, the general criteria of preparing teachers are partly traditional, manifested in knowledge, abilities and attitudes, and partly related to expected teacher competencies, broken down according to the following fields of competences:

- knowledge related to didactics and the given subject;
- supporting, organizing and controlling learning.

Another specific feature of the activity of vocational teachers is that they are allowed to teach not only in schools but also in non-formal vocational training. Hence, they have to be well prepared to teach age groups well outside the range of 14 to 18 year olds, when providing vocational training for young adults and adults or learners with special needs. Training teachers for teaching trade groups or using vocational contents related to particular sectors is hindered by the almost complete lack of textbooks that could support the teaching of professional subjects in vocational schools and vocational secondary schools. Thus,

teachers could only rely on the actual course requirements within vocational framework curricula. It justifies the need for putting content development for actual subjects and thus the development of a new didactics into the focus of educational development, facilitating both the training of vocational teachers and learning professions at school.

BME is a leading institution in Hungary in the training of vocational teachers and the continuous professional development of teachers, with excellent professional references. Teachers have been trained at BME for more than one and a half centuries. In the past 50 years, significant efforts have been made in the institution as well as at the Department of Technical Education to train vocational teachers, always taking care for also making the relevant developments in didactics. Based on these, BME's Teachers' Training Centre started its operation in December 2012, according to the requirements of the Act on Higher Education, in the framework of BME's Faculty of Economic and Social Sciences (GTK) and continuing the work of the Department of Technical Education.

New Approaches to Research

The *in situ* analysis of the history of the issue as given above and the interpretation of parabolas in communication situations led to tackling the practical problems of visual learning from the aspect of education. Improving the efficiency of an education system predominantly relying on verbal contents may represent quite a challenge due to the lack of the necessary time and information and the slowness of correction mechanisms in the case of traditional curricula, as it was proved by several methodology experiments (cooperative methods, project based work, connectivism⁸ in learning). Even "modern" curricula that had been developed by the end of the 20th century had a linear structure and the prevailing dominance of verbal contents (80% on average) was changing only slowly, giving way to visual contents which in turn were mostly composed of static pictures. Though online curricula and multimedia-based e-learning representations include more dynamic visual contents (flash, video), the "logic" of curricula design has not changed in our opinion. Visual contents are still considered as mere supplements to verbal (written and oral) messages.

An alternative to the curriculum design paradigm drafted above may be increasing the ratio of visual elements in order to increase the volume of information. However, the ratio cannot be altered just randomly. Changes should fit into the parabolic equations, assuming that both formats (verbal and visual) are required by learners and their ratio is the same for a given subject, age group and other conditions.

The best example may be the most widely known parabolic function, where the amount of verbal information is plotted on axis x while the amount of visual information (that is able to convey significantly more information) is plotted on axis y . These are able to define a *focus (F)* both in theory and reality, corresponding to a relevant *knowledge element (Tf)* as discussed previously.

Regarding methodological questions, with special regard to mathematics and other disciplines of natural sciences and the related applied sciences such as technical sciences and their applications, curricula are based on descriptive verbal elements (**Text – V**) that are supported by visual elements (**Pictures – P**) and mathematical formulas (**Math – M**).

⁸ G. Siemens, "Connectivism: A learning theory for the digital age", *International Journal of Instructional Technology and Distance Learning*, 2005, http://www.itdl.org/journal/jan_05/article01.htm.

Traditional curricula (published in the format of textbooks) usually include the combination of these, structured in a rigid linear sequence, such as ‘explanation, figures, formulation, explanation’ and so on. Often only random examples are given as case studies (**Case – C**) to illustrate practical applications. Even tests to facilitate practicing follow this structure or they are provided in a sequenced order.

- In the framework of our ongoing research to develop new curriculum designs, we use online tools and methods to present knowledge elements ($T_{f_1}...T_{f_n}$) in a virtual space instead of the traditional sequenced order (that obviously used to be also a prerequisite for printing). In this virtual space, the $T_{f_1}...T_{f_n}$ knowledge elements are placed on the surface of a sphere and positions are not defined by moving them but adding more and more elements. The visual representation applied for the virtual encyclopedia clearly demonstrates the connections between the individual entries that create a system similar to a scale-independent network. An example of this method is the Magyar Virtuális Enciklopédia (Hungarian Virtual Encyclopedia, <http://www.hunfi.hu/nyiri/enc>), a result of a development process realized decades ago that is still able to demonstrate the success of the method.
- For a curriculum design developed in *open access*, cloud services offer a development infrastructure surpassing all previous solutions. This far we used series like

T – P – M

sometimes supported with practical examples

T – P – M – C

Showing other connections between these elements to develop a dynamic network was typically hindered by disciplinary and temporal restrictions.

Basing on our current development and the relevant hypothesis, the new curriculum may greatly facilitate the acquisition of knowledge and its control. This new curriculum, where verbal and visual elements are presented in a one to one ratio and knowledge elements are organized into a network, would be scale-independent and structured as a graph; it would also be supported by a mathematical representation to enhance both its theoretical and practical aspects and users would be allowed to extend it by case studies and practical examples. For each element of this knowledge set formulated in the virtual space in a graph structure, a *comics* would be assigned, comics being a solution that combines verbal and visual information as well as being paralleled **by** a mathematical representation and adjustable for the needs of the given age group. These knowledge elements, to be verified upon a broad professional basis, would basically summarise theoretical and general information in a modern form, yet in an optimum volume. As a result of the open structure, the new system is obviously more suitable for incorporating new and interdisciplinary knowledge elements than traditional solutions. Another important characteristic of this knowledge representation process is increasing the efficiency of acquiring knowledge by means of making dry theoretical knowledge more lifelike adding case studies, good practices and examples to it which in turn are the results of social content development. The parable of visual learning becomes reality at this point. The verbal dominance in the current traditional education framework cannot be overcome due to reasons like tradition, methodology culture, generations of textbooks, whereas in the new system the ***T–P–M*** knowledge structure, originally restricted both in space and “volume” may be supported by a ***C*** set of case studies unlimited regarding the number and nature of examples, where practicality and the need for illustration ab ovo presumes the dominance of visual elements.

Our concept aims at providing a major storage medium by means of cloud services, as needed by the curriculum that is being developed using the open access approach. This way, a development infrastructure superior to any former attempts can be provided for teachers, teacher trainees or even students involved in developing didactics or learning contents in the medium term.

Based on the current developments, our hypothesis states that knowledge elements interlinked at the level of micro-contents will form a complex curriculum. The practical application of micro-contents as micro learning elements is justified by the new habitual ways of gaining information by means of the smart devices generally used now. Common features of the most popular mobile communication applications are the offering of instant experience, direct communication with friends and others using the same application, and customized "quantum" of received knowledge. This customization depends on the size and resolution of the mobile device's screen, the limitations of the user's divided attention, the design of the user interface and the way the user attempts to eliminate environmental disturbance resulting from being in motion while using the device.

Another feature of modern mobile communication is that digital information can be "recycled" that is shared among connected people. There are several mobile applications that support the unlimited accumulation of information (Facebook, Pinterest). This is a fixed use of mobile devices, mostly practiced by the young generations, that appears to be a yet unexploited opportunity in Hungarian education. Micro-learning as such is already known in Hungary from international practical examples (duolingo – learning foreign languages); however, there is no relevant methodology specifically adapted to Hungarian conditions.

Micro-learning presumes the generation of micro-contents and constructing their relevance network. Using these methods, traditional learning contents may be customized in a digital format for the screen of mobile devices and the context of these contents may be displayed for students like a hypertext. Knowledge elements may be collected and copied into sets of contents; these sets may be then analyzed, estimating the quality of the entire curriculum regarding its contents and configuration.

Curricula that can be modelled as a scale-independent graph (that is connected visual and verbal knowledge elements) combined with mathematical representations to enhance both theoretical and practical approaches, as well as case studies and practical examples, also added by the users themselves, may significantly promote acquiring and controlling knowledge. Accordingly, verbal explanations, visual representations easily understood by young people and mathematical representations adjusted to the relevant age group would be supplied to each element of the graph-like knowledge set formulating in virtual space. These knowledge elements, formed on a broad professional base but verifiable by the culture of didactics of teachers would summarize theoretical and general information in a modern format and in optimum quantity. As a result of its open structure, it is easier to add knowledge elements related to new or interdisciplinary contexts in this system than in traditional ones. Other important characteristics of this knowledge representation process are improving the efficiency of acquiring knowledge by applying case studies and examples and accelerating targeted content development by the community (students and teachers). Case studies, best practices and practical examples may render learning and the curriculum itself more realistic, compared to the current, apparently often too theoretical approach.

Another significant feature of the research regarding didactics is the use of cloud based services i.e. storing the complex *open access didactics material* (that is being expanded continuously regarding both the number of elements and their connections) in a cloud. It is

thought to provide services for users in schools that are not restricted to one dedicated piece of hardware but to several ones owned by the service provider, guaranteeing the continuous availability of redundant servers combined with an efficient protection against data losses.

Cloud services appeared in the 2010s on the IT market and the number of cloud service providers has been rapidly increasing lately, while state-of-the-art ICT tools facilitate their use for everyday purposes. The most frequently cited advantages of cloud based solutions are reliable and cost efficient implementation and operation, 80-90% exploitation of the available capacity, low investment costs and unlimited computer resources.

Cloud based systems generally attempt to establish cross links between various services. This is an essential feature of the system as this way a particular service has access to contents generated in another one so users do not have to bother with uploading all the necessary data and information when starting a new application. The most important feature of the *open access* application principle is free availability where the progressive use of security protocols is not required. Other advantages of this approach are the possibility of collaboration, continuous synchronizing and saving of data, automatic updates, shared contents and encryption.

In cloud based data storage, several data storage providers are available, all of them specialized at using a particular platform, working in full harmony with the given operating system. For example, the possibly most widely used storage providers in global comparison are Google Drive combined with the Android operating system, Dropbox with iOS systems and OneDrive with the increasingly popular Windows phone operating system. The projected rate of increase in cloud based services will exceed that of general IT technologies multiple (four or five) times. This is why curriculum and learning content development at BME focuses on generating visual contents by professional communities (teachers' development programs) when developing vocational contents at BME.

The strategic concept of these developments is being elaborated currently. The first design of this kind is being developed for the new online curriculum "Introduction into Systems" for teachers working in secondary education. *Our hypothesis can be summarized as follows: visual learning may provide opportunities to use parables that are able to improve the efficiency of human learning, currently based on traditional verbal communication and as such hindered by time constraints and information pressure.*

Conclusion

The most up-to-date interpretation of the never ceasing debate that was provoked by Ferguson's [*Engineering and the Mind's Eye almost half a century ago*](#) points out how poorly our current education paradigm is able to exploit the potential of visual learning. The historic experiences in interpreting and using parables called the attention to the fact that these two methods of communication do not necessarily contradict each other as educational tools. Indeed, state-of-the-art interpretations of learning make us abandon teaching traditions when designing new curricula and exploit the new technical options offered by our digital environment, providing learners with a flexible, continuously developing system where proven methods are available to extend the set of relevant practical examples. Applying visual learning in the framework of this approach, we may fully utilize its potentials in

creating opportunities to develop for those who want to hand over knowledge and those who wish to acquire it.

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- [3] Cf. <http://www.nottingham.ac.uk/visualearninglab/visualearninglab.aspx>, *Showcase of Innovations in Visual Learning*. Nottingham University, 2010.
- [4] András Benedek and Kristóf Nyíri (eds.), *Images in Language: Metaphors and Metamorphoses* (series Visual Learning, vol. 1), Frankfurt/M: Peter Lang, 2011, 205 pp. – András Benedek and Kristóf Nyíri (eds.), *The Iconic Turn in Education* (series Visual Learning, vol. 2), Frankfurt/M.: Peter Lang, 2012, 164 pp. – András Benedek and Kristóf Nyíri (eds.), *How to Do Things with Pictures* (series Visual Learning, vol. 3), Frankfurt/M.: Peter Lang, 2013, 224 pp. – András Benedek and Kristóf Nyíri (eds.), *The Power of the Image: Emotion, Expression, Explanation* (series Visual Learning, vol. 4), Frankfurt/M.: Peter Lang, 2014, 287 pp.
- [5] His latest edited book is the volume *Living Inside Mobile Social Information*, Division of Emerging Media Studies, College of Communication, Boston University, <http://us8.list-manage.com/track/click?u=2fe8f203b1eb854924a38e031&id=a91e508b8c&e=94aa0f2163>.
- [6] Cf. e.g. Kristóf Nyíri, “Images in Conservative Education”, in Nyíri, *Meaning and Motoricity: Essays on Image and Time*, Frankfurt/M.: Peter Lang, 2014.
- [7] Cf. <http://en.wikipedia.org/wiki/Parabola> (see Figure 1).
- [8] G. Siemens, “Connectivism: A learning theory for the digital age”, *International Journal of Instructional Technology and Distance Learning*, 2005, http://www.itdl.org/journal/jan_05/article01.htm.

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DIGITAL LITERACY: IS DIGITAL READING SIMILAR TO COMIC READING?¹

Preface

As a result of technological innovations, the way we think, the way we comprehend texts is constantly changing. The new forms of media have a strong effect on our cognitive processes. The visual elements, pictures, gifs, icons, short videos and interactive adverts significantly influence our ability to read and understand texts. This is the reason why so many researchers try to capture the essence and the effects of the recent changes of the digital environment.²

In my paper I will focus on digital reading literacy concerning the visual elements of comprehension. My main question is whether digital reading is similar to comic reading. In my essay I will argue that reading digital texts containing visual elements is a non-linear kind of reading which is indeed very much like comic reading. In order to prove my hypothesis, I will start with giving some definitions for some fundamental expressions (digital text, visual elements, non-linear reading, and comics) which I will constantly use in my work. Secondly, I will draw up the main characteristics of digital reading in accordance with the latest literature. Then I will give a short summary of the specifics of comic reading. Finally, I will make a comparison between comic reading and digital reading focusing on their similarities. In the end of my paper I will provide a prognosis for further possible research, too. My aim is to get a better understanding of digital literacy and reading process.

Introduction, hypothesis

As a starting point I have to make it clear that visual elements which appear on digital interfaces have strong effects and influence on our cognitive processes, especially on reading and text comprehension. My aim is to get a better understanding of these elementary changes.

I have two basic questions:

1. Do we read in a new kind of way, therefore we need new types of texts?
2. Do we have new types of texts; therefore we need to read in new kinds of ways?

To answer these questions, I should find a common point of printed and digital texts/printed and digital reading.

¹ This research progresses in the framework of the Integral Argumentation Studies (OTKA – K-109456) of the Doctoral School of Philosophy and History of Science, Budapest University of Technology and Economics.

² Mary C. Dyson and Gary J. Kipping, "Exploring the effect of layout on reading from screen", in Roger D. Hersch, Jacques André and Heather Brown (eds.), *Electronic publishing, artistic imaging, and digital typography: Seventh International Conference on Electronic Publishing: Proceedings*, Berlin: Springer-Verlag, pp. 294–304; Karen Coyle, "Managing Technology: Meaning, technology, and the semantic web (2008)", <http://www.sciencedirect.com/science/article/pii/S0099133308000426>, last accessed 25. 01. 2015); William C. Dougherty, "Managing Technology, The book is dead, long live the book!" (2011), <http://www.sciencedirect.com/science/article/pii/S0099133311001959>, last accessed 25. 01. 2015; Eve Bearne, Chris Clark, Annette Johnson, Penny Manford, Marilyn Mottram and Helen Wolstencroft with Rosemary Anderson and Nikki Gamble, *Reading on screen*. Leicester: United Kingdom Literacy Association, 2007.

Reviewing the related literature about reading, text typologies and comprehension, I started to be interested in the forms of special digital texts (short messages, e-mail letters, posts, comments, and comics) because I think that their similarities and differences are particularly suitable for discovering digital reading processes. As a confirmation for this I found a promising idea by Tamás Dunai: “Reading comics [on all the digital multimedia tools mentioned above] can be compared mostly to the active user activity of the Internet.”³ This idea suggested the following question: what if I carry on this analogy in a much more focused way, comparing the reading process of comics to the reading process of digital texts? I did a research on this question and finally I came up with the following hypothesis: *reading digital texts containing visual elements is a non-linear kind of reading which is similar to comic reading*. Henceforth my aim is to confirm this statement.

Definitions: digital text, visual elements, non-linear reading, comics

At this point it is necessary to define some expressions which I will constantly use in my essay. The importance of this definition process lies in my intention of giving an unequivocal paper about my thesis. The expressions in question are the following: digital texts, visual elements, non-linear reading and comics.

The first basic notion is *digital text*. I take digital text to be a text which we can read on the display of our e-book or other technological devices like PCs, notebooks, tablets, cell phones and smart phones. They also include e-bills and every text on websites (Figure 1). In plain words: digital texts are texts stored as strings of characters on a technological device.⁴



Figure 1: Examples of digital texts

Digital texts are hypertexts⁵; in other words, networks of web links which spread all over the online space.⁶ They are also hybrid texts,⁷ which means they are a kind of design product

³ Tamás Dunai, “Képregény Magyarországon” [Comics in Hungary], *Médiakutató*, Spring 2007, http://www.mediakutato.hu/cikk/2007_01_tavasz/02_kepregeny_magyarorszagon, last accessed 14. 01. 2015.

⁴ Razia Pullen, “Technology Tools for Reading. Technology Tips for Differentiated Instruction”, *JRF/2006*, p. 2, <http://www.broward.k12.fl.us/studentssupport/ese/PDF/Whatisdigital.pdf>, last accessed 14. 01. 2015.

⁵ Barry W. Cull, “Reading revolutions: Online digital text and implications for reading in academe”, *First Monday*, vol. 16, no. 6, June 6, 2011, <http://firstmonday.org/ojs/index.php/fm/article/view/3340/2985>, last accessed 14. 01. 2015; Jay Bolter, *Writing space: The computer, hypertext, and the history of writing*, Hillsdale, NJ: Lawrence Erlbaum, 1991; Jay Bolter, *Writing space: The computer, hypertext, and the remediation of print*, second edition, Mahwah, NJ: Lawrence Erlbaum, 2001.

⁶ Barry W. Cull, “Reading revolutions: Online digital text and implications for reading in academe”, *First Monday*, vol. 16, no. 6, June 6, 2011, <http://firstmonday.org/ojs/index.php/fm/article/view/3340/2985>, last accessed 14. 01. 2015; Jay Bolter, *Writing space: The computer, hypertext, and the history of writing*, Hillsdale, NJ: Lawrence Erlbaum, 1991; Jay Bolter, *Writing space: The computer, hypertext, and the remediation of print*, second edition, Mahwah, NJ: Lawrence Erlbaum, 2001.

for the readers. Reading a digital text is a constitutive, constructive and transforming process when syntax and semantics, such as cohesion and coherence function in a special form.⁸ Cohesion means the syntax at the macro level of expressions, the predicative structure and the connection of sentences. At micro level it refers to the relationship of single phrases and grammatical units. Coherence is the meaning of the text, not just the possible interpretations of the expressions but also the meaning and knowledge in context.⁹ Because of these features it is required to reconstruct the definitions of writing and reading that is the main topic of numerous current researches.¹⁰

The second important expression is *visual element*. I consider visual elements to be pictures, graphics, and any kind of design elements of a website, word clouds and gifs. The interactive advertisements and the graphical elements of a Prezi or a Power Point presentation are also visual elements, such as the statistics vector icons, the smart art pictures, the opening pictures of a notebook or a smartphone with all their colourful and dynamic icons. In my view even an embedded YouTube video counts as a visual element (Figures 2 and 3).



Figure 2: Examples of visual elements

However, here it is very important to mention that digital literacy surveys such as PISA-tests (the regular international surveys of the Program for International Student Assessment) examine only those visual elements which are explicitly and essentially connected to a

⁷ Maureen Walsh, "Multimodal literacy: What does it mean for classroom practice?", *Australian Journal of Language Literacy*, vol. 33, no. 3 (October 2010), p. 224.

⁸ Barry W. Cull, "Reading revolutions: Online digital text and implications for reading in academe", *First Monday*, vol. 16, no. 6, June 6, 2011, <http://firstmonday.org/ojs/index.php/fm/article/view/3340/2985>, last accessed 14. 01. 2015; David L. Ulin, "The lost art of reading", *Los Angeles Times*, August 9, 2009, <http://articles.latimes.com/2009/aug/09/entertainment/ca-reading9>, last accessed 14. 01. 2015.

⁹ Barry W. Cull, "Reading revolutions: Online digital text and implications for reading in academe", *First Monday*, vol. 16, no. 6, June 6, 2011, <http://firstmonday.org/ojs/index.php/fm/article/view/3340/2985>, last accessed 14. 01. 2015; David L. Ulin, "The lost art of reading", *Los Angeles Times*, August 9, 2009, <http://articles.latimes.com/2009/aug/09/entertainment/ca-reading9>, last accessed 14. 01. 2015.

¹⁰ Maureen Walsh, "Multimodal literacy: What does it mean for classroom practice?", *Australian Journal of Language Literacy*, vol. 33, no. 3 (October 2010), p. 224.

written text.¹¹ But in my view, visual elements are all the visual contents which appear in the context of a text as additional, explicative or illustrative elements.



Figure 3: Examples of visual elements

Now it is time to define what does *non-linear reading* mean, which is the most important characteristic relevant to digital texts. In the history of reading, the current usage of digital devices represents the biggest change at the level of media.¹² This is true particularly for the ramified nature of the text. This basic difference compared to the printed text implies the greatest difficulty in reading and understanding digital texts.

Non-linear reading is a special kind of reading. It is fragmental, scanning, superficial, bouncing, simultaneous, information sorting, fast and pictorial. It concentrates on the individual elements and also on the users. Non-linear reading primarily facilitates rapid information searching rather than in-depth reading. This new reading strategy was created as a result of the hypertext where intertextuality enters another dimension.¹³

A special way of reading: comics

¹¹ Ildikó Balázs et al., *A PISA2009 tartalmi és technikai jellemzői* [Material and technical features of PISA2009], Budapest: Oktatási Hivatal, 2010, https://www.oktatas.hu/pub_bin/dload/kozoktatás/nemzetközi_merések/pisa/A_PISA2009_tartalmi_es_techikai_jellemzoi.pdf, last accessed 25. 01. 2015.

¹² Terje Hillesund, "Digital reading spaces: How expert readers handle books, the Web and electronic paper", *First Monday*, vol. 15, no. 5 (April 5, 2010), <http://firstmonday.org/article/view/2762/2504>, last accessed 14. 01. 2015.

¹³ Krisztina Szabó, "A digitális szövegértés felmérése – A 2009-es PISA-teszt definíciós problémái" [Digital Literacy Survey – The definitional problems of the 2009 PISA test], to appear in 2015.

Finally I will define what I call *comic*. Comic is a part of literature and fine art, too (Figure 4). But – what is more important – comic is a medium¹⁴ which we have to read in a special way. I said medium because none of its narrative systems is merely additional. We read it in a special way because we have to discover the narrative connections among pictures.¹⁵



Figure 4: Examples of comics

Comics are based on the coexistence of texts and visual elements, namely pictures. “Often textual devices such as speech balloons, captions, and onomatopoeia indicate dialogue, narration, sound effects, or other information. Size and arrangement of panels contribute to narrative pacing.”¹⁶ By using frames or panels they illustrate the story, facilitate comprehension, complete the meaning and make organic unit with it. It may occur that:

1. Text and pictures have got no sense without one another. And also that:

¹⁴ Allison Sivak, “Across Time and Space: Reading Comics”, 2003, <http://capping.slis.ualberta.ca/cap03/allison/othermedia.htm>, last accessed 14. 01. 2015; Tamás Dunai, “Képregény Magyarországon” [Comics in Hungary], *Médiakutató*, Spring 2007, http://www.mediakutato.hu/cikk/2007_01_tavasz/02_kepregeny_magyarorszagon, last accessed 14. 01. 2015.

¹⁵ István Koós, “A képregény mint sajátos kifejezési forma” [Comics as a particular form of expression], *Kalligram*, vol. 13, Feb. 2004, <http://www.kalligram.eu/Kalligram/Archivum/2004/XIII.-evf.-2004.-februar/A-kepregeny-mint-sajatos-kifejezesi-forma>, last accessed 14. 01. 2015.

¹⁶ Wiki: *Comics*, http://en.wikipedia.org/wiki/Comics#Comics_studies, last accessed 14. 01. 2015.

2. Text and pictures communicate different things to the reader at the same time.¹⁷

Here it is essential to mention that there are many types of comics according to cultures and languages. “Cartooning and similar forms of illustration are the most common image-making means in comics; fumetti is a form which uses photographic images. Common forms of comics include comic strips, editorial and gag cartoons, and comic books. Since the late 20th century, bound volumes such as graphic novels, comics albums, and tankōbon have become increasingly common, and online webcomics have proliferated in the 21st century.”¹⁸

Below a short list of comic types can be found.¹⁹

- Abstract Comics
- Caricature
- Crime Comics
- Editorial / Political Cartoons
- Graphic Novels
- Horror Comics
- Ligne clair (“clear line”)
- Manga
- On-Line / Web Comics
- Political Cartoons
- Romance Comics
- Science Fiction Comics
- Super Heroes (Superheroes, Super Villains, Super)
- Tijuana Bibles / “Eight-Pagers”
- Underground / Alternative Comix
- War Comics
- Western Comics
- Wordless Comics / Mute Comics / Silent Comics
- ‘Zines

Now I won’t say more about the typology of comics, because it would lead us far from our central question. At this basic level it is enough that they share more or less the same characteristics as mentioned above.

Comparison: comic reading vs. digital reading

I shall now advert to another matter, namely the comparison between comic reading and digital reading. My aim is to find sufficient similarities among the characteristics of the two reading processes.

According to the literature we can say that comic reading is a fragmental, non-linear reading where even the linear plot is not cognizable in a linear way. It depends on the reader whether s/he looks at the visual elements or the text firstly, or what part of the visual elements s/he starts with. According to the comic types the reader can decide on the

¹⁷ Tamás Dunai, “Képregény Magyarországon” [Comics in Hungary], *Médiakutató*, Spring 2007, http://www.mediakutato.hu/cikk/2007_01_tavasz/02_kepregeny_magyarorszagon, last accessed 14. 01. 2015.

¹⁸ Wiki: *Comics*, http://en.wikipedia.org/wiki/Comics#Comics_studies, last accessed 14. 01. 2015.

¹⁹ ComicsResearch: <http://www.comicsresearch.org/genres.html>, last accessed 14. 01. 2015.

direction of reading in spite of the fact that comics are narrative texts, and they usually intend to tell a story. But thanks to the special structure of comics, readers do not have to stick strictly to the story line during the reading process. The elements of a comic are open and freely walkable by the reader.²⁰ This process is a kind of scanning where readers handle the complexity of text and pictures as a map for getting the relevant and interesting information which they need in order to understand the story. The cause behind this fact is that comic is a “hyperpicture”, in other words: a web of pictures. This is especially true for the webcomics which we can read online with the help of a digital device. It is also true that comic is a “hybridpicture”, a design product in which cohesion and coherence function in a special way.²¹

As we can see from these facts mentioned above, when we read a comic text, text reception needs an active user activity. Moreover, to understand and use the integration of pictures and text we need some sort of visual literacy. From this point of view it seems to me that reading comics and reading digital texts are similar processes. The importance of connecting pictures and texts can be similar in both cases. They give additional meaning and information one another, some kind of help for the sake of better understanding. Pictures and other visual elements have an essential function in guiding the reader’s attention.

Why is this so important? Because reviewing the literature it can be seen that some researchers of digital reading are suspicious about the enormous amount of visual elements in digital texts. They think that the lots of illustration make the process of clear understanding difficult like a kind of digital noise. In the world of motion pictures and video games we get ready-made products, hence we don’t have to use our cognitive processes as hard as when we read and think while being guided by our own fantasy. They say that too much visual effects lead us – particularly the children – back to picture reading which is a less effective, more superficial and already outdated way of reading, hence thinking. However that may be, in the case of comics the visual elements play an essential additional role in the reading process and they do not distract our attention but on the contrary: they help us in deep reading and complex understanding. If so then why couldn’t the visual elements in a digital text work in the same way? If my hypothesis is true and the two reading processes (digital and comic) are similar then we can take a step forward in understanding our modern reading and cognitive mechanisms.

Even so, I think that I should examine this similarity in a critical way, too. So here are some possible objections:

- Comics are narrative texts; their aim is to tell a story, whereas digital texts have got numerous other functions and aims.
- Reading a story, getting informed and acquiring knowledge are not the same processes.
- There are too many types of digital texts and comics so it can be problematic, leastwise difficult to draw a strict parallel between them.

²⁰ E. J. Aarseth, “Nonlinearity and Literary Theory”, in *Hyper/Text/Theory*, ed by George Landow, Baltimore: Johns Hopkins University Press, 1994.

²¹ Nóra Kovács, *WebcoMix: Képregények az interneten* [WebcoMix: Comics on the Internet] (2009), http://epa.oszk.hu/01500/01515/00006/pdf/mediarium-iii_3-4_07.pdf, last accessed 14. 01. 2015.

However, nowadays comics are increasingly used for dissemination and for illustrating educational material.²² So they could have not only narrative, but also descriptive, explicative and informative functions. But I acknowledge that the similarities between the processes of comic reading and digital reading are questionable in some aspects, so I think that further research is required.

In Chart 1 I summarize some elements of comparison in.

	DIGITAL READING PROCESS	COMIC READING PROCESS
SIMILARITIES	fragmental, non-linear, scanning, the elements of a comic are open and freely walkable by the reader, hypertext/picture, hybridtext/picture, design product, special cohesion and coherence, active user activity	
DIFFERENCES	numerous text types, numerous aims and intentions of the authors for example: getting informed, acquire knowledge etc.	narrative texts, their aim is to tell a story

Chart 1. Comparison: digital reading vs. comic reading

Conclusion, a prognosis for possible further research

In my paper I focused on digital reading literacy concerning the visual elements of comprehension. My main question was whether digital reading is similar to comic reading. I argued that reading digital texts including visual elements is a non-linear kind of reading which is actually very much like comic reading. First I gave some definitions for the fundamental expressions which I constantly used in my work. Secondly I drew up the main characteristics of digital reading in accordance with the latest literature. Then I gave a short summary about the specifics of comic reading and made a comparison between comic reading and digital reading focusing on their similarities.

As a conclusion I can say that having examined comic reading and digital reading, I should modify my hypothesis a little bit, which is now the following: *reading digital texts including visual elements is a non-linear kind of reading which can be similar to reading comics.*

What should be the next step? As a prognosis for possible further research I think that I should examine the different kinds of comics types and also the eye-tracking heat map researches which try to capture the tracks of our reading processes.

Concerning the future: what follows from the comic book-like reading literacy? On the one hand, this is another step of mapping the process of digital text reception processes. On the other hand, it can help in reconsidering the development of writing digital educational material. What is more, I hope that this research direction could find answers to my two fundamental questions which I posed in the beginning, namely:

- Do we read in a new kind of way, therefore we need new types of texts?

²² Gyula Maksa, "Ismeretterjesztés és képregény" [Comics and disseminating information], *Médiakutató*, Spring 2007, http://www.mediakutato.hu/cikk/2007_01_tavasz/01_ismeretterjesztes_es_kepregeny, last accessed 14. 01. 2015.

- Do we have new types of texts; therefore we need to read in new kinds of ways?

At this point I firmly think that the answers for both questions are yes. It seems to me that reading processes and text types are closely related in a circular way: one follows from the other insofar as one defines the other. But in order to realize this connection we need to reconsider our ideas about literacy. Hereinafter I would like to do further researches on this topic.

Acknowledgements

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SZLÁVI, Anna

METAPHORS MATTER
THE ANALYSIS OF PREZI IN SEARCH OF VISUAL-VERBAL METAPHORS

For us, academics, whether we are young scholars or experienced professors, giving a presentation is a never-ending challenge. We often feel intimidated not only when facing our audience but also when preparing our visual support. As a frequent conference-participant, I became fascinated by the diversity of presentation visuals, both in style and quality. This fascination later led me to the idea of investigating presentation tools, mainly to see how the characteristics of a software helps or hinders the presentation-making process. In my search I discovered an online presentation tool whose popularity has shown an impressive growth over the past years. It is not just its soaring global expansion that makes Prezi an exciting topic for analysis. The fact that two of its founders are from the same university as the editorial board of this journal makes the present examination a perfect fit for the first international issue.

Prezi Matters

What is Prezi then and why does it matter? Prezi¹, at www.prezi.com, is a cloud-based presentation software, known mainly for its zooming feature. It offers much more, though. It offers immense spatial freedom for structuring and communicating our ideas. On an infinite canvas, we are invited to place and manipulate text, image, and audio-video materials wherever and however we feel like. We can group them into units based on what we consider to belong together. Then, by creating paths between these units, we create navigational sequences, thus putting our dynamic presentation into a linear-like display order.

What really makes a difference, compared to the well-known rival, PowerPoint, is Prezi's zooming user interface. As if having a camera, we can pan through our surface freely, zooming in or out, depending on whether we want to see the details or the whole picture. This feature is amazingly helpful both when trying to structure our thoughts into a presentation, that is, in the process of making the presentation, and when trying to explain our thoughts to the audience, that is, in the process of understanding. It is so because Prezi blends two important characteristics of how we learn and process information: we remember landmarks, and we combine landmarks with direction or action.²

¹ When referring to the software or the company, *Prezi* is capitalized; otherwise, when referring to individual presentations made with this software, *prezi* is used.

² J. Koetsier, "Prezi Hits 30M Users, Doubling Annually, and Has 'Not Used a Dime' of Investors' Money". *Venturebeat.com*. Posted Nov. 14, 2013, retrieved 10 Jan. 2015: <http://venturebeat.com/2013/11/14/prezi-hits-30m-users-doubling-annually-and-has-not-used-a-dime-of-investors-money>.

Not only can we zoom and pan in Prezi, we are also free to rotate and size both our elements and our units as we see fit. Thus, Prezi's Flash- (and recently JavaScript-)based software³ offers a huge amount of creative freedom to its users.

And users seem to appreciate it. The company, which was launched in 2009 by co-founders Szabolcs Somlai-Fischer, Péter Halácsy, and Péter Árvai, with the support of Kitchen Budapest and Magyar Telekom, has been presenting incredible growth. First with headquarters in Budapest, Hungary, given that the co-founders, an architect, a computer scientist, and an entrepreneur, are Hungarian, Prezi opened its second office in San Francisco, California, in the same year. After gaining the sponsorship of TED, a series of conferences focusing on the themes of Technology-Education-Design and on the notion of Ideas (are) Worth Spreading (which is why all talks are accessible online for free), Prezi started its global expansion (www.ted.com).

Since 2009 Prezi has opened several offices all around the world and has become available in multiple languages, like Hungarian, Spanish, Portuguese, German, French, Korean, and Japanese, next to English. The most impressive data, however, is the number of signups Prezi is producing from year to year. In October 2013, a headline reported: "Prezi's current 30 million users is a 50 percent increase in just six months, and 1.5 million new users are currently joining the company every month" (Koetsier). In April 2014, the company reached a new landmark with its 40 million users, which translates into 55,000 new signups each and every day.⁴

What is the secret behind this soaring popularity? According to Prezi's motto, "ideas matter". What is then the idea that brought and is still bringing Prezi success?

Theories Matter

As an active user of Prezi and a researcher of cognitive science, I have developed a hypothesis in search of an explanation for Prezi's skyrocketing statistics. My hypothesis can be divided into two sub-theories.

Hypothesis 1: Prezi offers a metaphorical tool.

As a researcher of metaphors, I always had the feeling, whenever using Prezi, that it is full of them. Metaphor is a basic conceptual process present in language, image, and culture;⁵ in other words, we communicate and think in metaphors. From this comes the second part of my hypothesis.

Hypothesis 2: Prezi's metaphorical tools play a significant role in its popularity.

³ P. Halácsy, "How and Why Prezi Turned to JavaScript – And Why It Took Four Years". *Prezi Engineering*. Posted July 1, 2014, retrieved 10 Jan 2015: <https://medium.com/prezi-engineering/how-and-why-prezi-turned-to-javascript-56e0ca57d135>.

⁴ M. Butcher, "Prezi Puts On 10M Users Inside 5 Months, Hits 40M". *Techcrunch.com*. Posted Apr. 9, 2014, retrieved 10 Jan. 2015: <http://techcrunch.com/2014/04/09/prezi-puts-on-10m-users-inside-5-months-hits-40m>.

⁵ G. Lakoff and M. Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, New York: Basic Books, 1999; Z. Kövecses, *Metaphor: A Practical Introduction*, New York: Oxford University Press, 2002; C. Forceville, "Non-Verbal and Multimodal Metaphor in a Cognitivist Framework: Agendas for Research", in G. Kristiansen, M. Achard, R. Dirven and F. J. Ruiz de Mendoza Ibáñez (eds.), *Cognitive Linguistics: Current Applications and Future Perspectives*, Berlin: Mouton de Gruyter, 2006; Z. Kövecses and R. Benczes, *Kognitív nyelvészet [Cognitive Linguistics]*, Budapest: Akadémiai Kiadó, 2010.

If Prezi proves to model the way we think, it seems logical to presume that its popularity comes largely from its conceptual ergonomics: its use of the fundamental conceptual process, metaphor.

To test my hypotheses, I worked out a three-level examination process. Firstly, I set myself to scrutinize Prezi's website, searching how the company defines its service. Secondly, I turned to the analysis of the user interface, checking the details of what users are offered when making a prezi. Thirdly, I contacted the company for insider statistical data for research purposes. Following my request, I was given stats and samples, which formed the next level of my examination.

My goal was to explore the presence and use of metaphors, on the one hand. The essence of metaphor is that it helps to understand an abstract concept, like that of life, by connecting it with a more concrete, thus, more easily apprehensible, experience, for example, of a journey. People tend to perceive similarities in the features of life and journeys (they both have difficulties/obstacles, choices/crossroads, goals/destinations, etc.), which provides basis for their metaphoric connection.⁶ Sentences like *She has gone through a lot in life* or *We are **at crossroads*** embody this metaphoric relation. According to my theory, metaphors, such as the above LIFE IS A JOURNEY,⁷ will appear in the visual messages of prezis, just like they appear in our natural verbal expressions.

Next to metaphor, I was also interested in the characteristics of frames in Prezi. The idea behind a frame is that every meaning is relative and can only be understood within a certain context, which entails a whole range of related knowledge.⁸ The BALL, interpreted within the FOOTBALL frame, the MAGICIAN frame, or the BABY frame, activates a fundamentally different reading and associates fundamentally different emotions. I figured, the interpretation of presentational content will depend a lot on the frame chosen for the presentation. Similarly, the frame will also determine what kind of content can be used with it.

Philosophy Matters

First of all, the research called for a scrutiny of Prezi's website. I was looking for how the company defines its product and if any metaphorical reference surfaces in its philosophy. It turned out, Prezi's manifesto abounds in what I was seeking for.

"Prezi is a virtual whiteboard."

The company starts its self-definition with an obvious metaphor. Comparing the relevance of the software in our virtual world to the appearance of the blackboard in early schools, Prezi describes its software as an educational tool, coining the phrase "virtual whiteboard." Prezi, however, is not only an educational tool. It is also a means of communication.

"A visual story has a flow and narrative, where images and words work together to present an idea or lesson."

As the manifesto goes on, we find Prezi in another frame. It is not just the classroom but the wider context of communication which can be connected to Prezi's functions. As Prezi

⁶ Z. Kövecses, *Metaphor: A Practical Introduction*, New York: Oxford University Press, 2002.

⁷ Following cognitive linguistic traditions, I am using SMALL CAPITALS to indicate concepts, as opposed to word forms.

⁸ C. Fillmore, "Frame Semantics", in *Linguistics in the Morning Calm*, Linguistic society of Korea (ed.), Seoul: Hanshin, 1982.

tells its viewers a visual story of text and image, which has a flow and a narrative, storytelling and the metaphor COMMUNICATION IS STORYTELLING come into the picture.

“Visual context leads the viewer on a path of discovery.”

Prezi, the story-teller tool, has the power to take its audience on a journey. At this point the well-known LIFE IS A JOURNEY (or STORY IS A JOURNEY) metaphor is invoked and added to Prezi’s frame.

“Prezi’s 3-dimensional canvas is a virtual space where you can delve deeper and pan wider to broaden the conversation.”

Prezi’s essence is clearly its spatial dimension. Space is thought to contain *depth*, in terms of communication as well. Making use of the CONDUIT metaphor,⁹ Prezi’s more than 2-dimensional space gives more room for thoughts, so that *ideas can go through* more effectively.

“Prezi’s use of spatial metaphor helps your audience remember your content better. Each prezi is a place where you can use spatial metaphor to engage your audience’s memory.”

As we see, Prezi is admittedly built on spatial metaphors; prezis themselves are viewed as physical spaces which you can fill with your content and use as conduits for your messages. The purpose of (spatial) metaphors is to communicate more effectively, so viewers can make sense of and remember our messages better.

Co-founder Árvai points out that cognitive science plays a key role in how Prezi operates. Spatial relativity is something that enhances our ability to store and recall data, he summarizes.

As we read through the company’s manifesto, we can conclude that Prezi has strong metaphorical bases. It invokes metaphors such as COMMUNICATION IS STORYTELLING, LIFE/STORY IS A JOURNEY, VIRTUAL IS PHYSICAL, and COMMUNICATION IS A CONDUIT, on the more general level; and PREZIS ARE CONDUITS, PREZIS ARE CONTAINERS, and PREZIS ARE BOARDS, on the more specific level. As far as Prezi’s philosophy is concerned, the company defines its service to be strongly metaphorical. At this point, Hypothesis 1 seems to hold.

Templates Matter

It is one thing, however, what theory says; reality is another issue. Although we identified a pronounced connection with metaphors in its philosophy, we need to check how Prezi works in practice. We now move on to the examination of its user interface.

Whenever you want to make a prezi presentation, after setting up a profile at www.prezi.com for free, you bump into the following screen (Figure 1).

⁹ G. Lakoff and M. Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, New York: Basic Books, 1999.

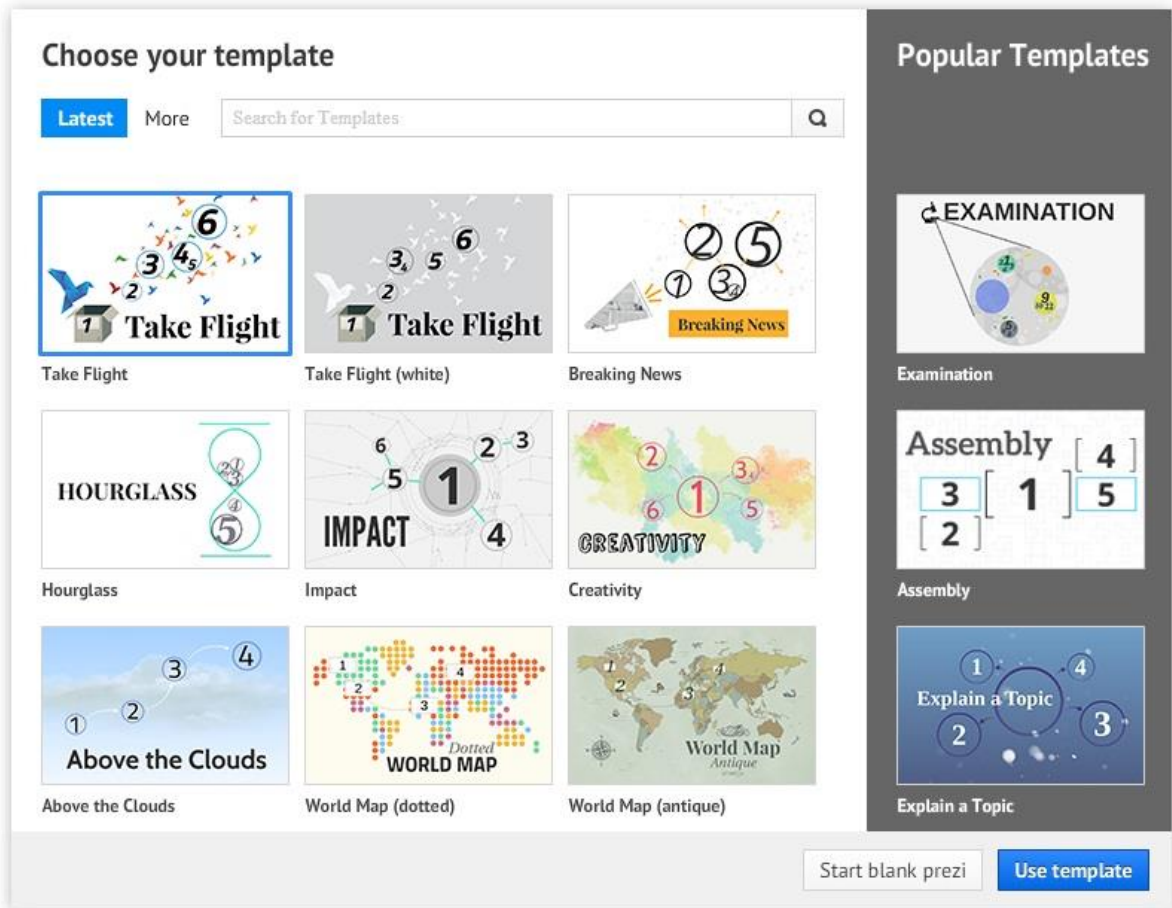


Figure 1: User interface at prezi.com

Before you can reach your infinite presentation canvas and start editing your prezi, you have to “Choose your template”. Prezi offers you 92 different, pre-designed templates, with various styles, themes, and contexts. Each of them has a title and a preview, which serve to give you an idea what the given template offers. You have, for example, “World Map”, with a given number of stops on different parts of the world. You can also choose “Tactics”, which is framed as a football pitch with a couple of players, two goals, and a ball on it. Simpler, more schematic templates are also available, like the tell-tale “Explain a Topic”, made up of 4 circles around a central circle, or “Impact”, with 6 linked circles, waiting for your content.

If you do not want to, you are not forced to use any of the templates. At the bottom left corner, there is a button saying “Start blank prezi”. By pressing it, you will arrive at a completely white canvas to be filled up by your content exclusively.

By considering the structure of the page from a UX (user experience) point of view, we realize how much templates are pushed to the fore, at the expense of the blank canvas. The multitude of the colourful preview pictures of the templates appears much more attractive and conspicuous than the tiny, almost hidden button of the blank. The reason for their central position is that templates are supposed to help and guide the user in how to make an effective prezi presentation. In addition to providing a frame for the content, they control (although not restrict) position, path, rotation, and zooming. Templates support the presentation-making process with design and organization.

Bearing their central role in mind, both on the page and in function, I turned to the analysis of templates as my next step. Out of the 92, I spotted 20 templates that seemed to resonate with well entrenched conceptual metaphors. The analysis revealed, not only do Prezi templates use metaphoric frames, but they belong to the same, structured, metaphor system.

The Event Structure Metaphor is a generic-level metaphor with image-schematic bases and a universal character.¹⁰ The central claim behind this system of metaphors is that many aspects of events, like changes, processes, actions, and causes are understood in terms of space, more precisely motion and force. These correlations are believed to be based on bodily experiences, thus, universal. Core metaphors such as CHANGE IS MOTION and CAUSES ARE FORCES manifest themselves in expressions like *The image **went** viral* and *The image **caught** everyone's attention*.

In the analysis of Prezi templates, the core metaphor proved to be PROCESSES ARE MOTIONS (a verbal example would be *He **went** blind at the age of 14*). Around this core metaphor, I could locate 10 other metaphors, from PROGRESS IS FORWARD/UPWARD MOTION through DIFFICULTIES ARE OBSTACLES to GOALS ARE DESTINATIONS. The metaphor system is illustrated in Figure 2.

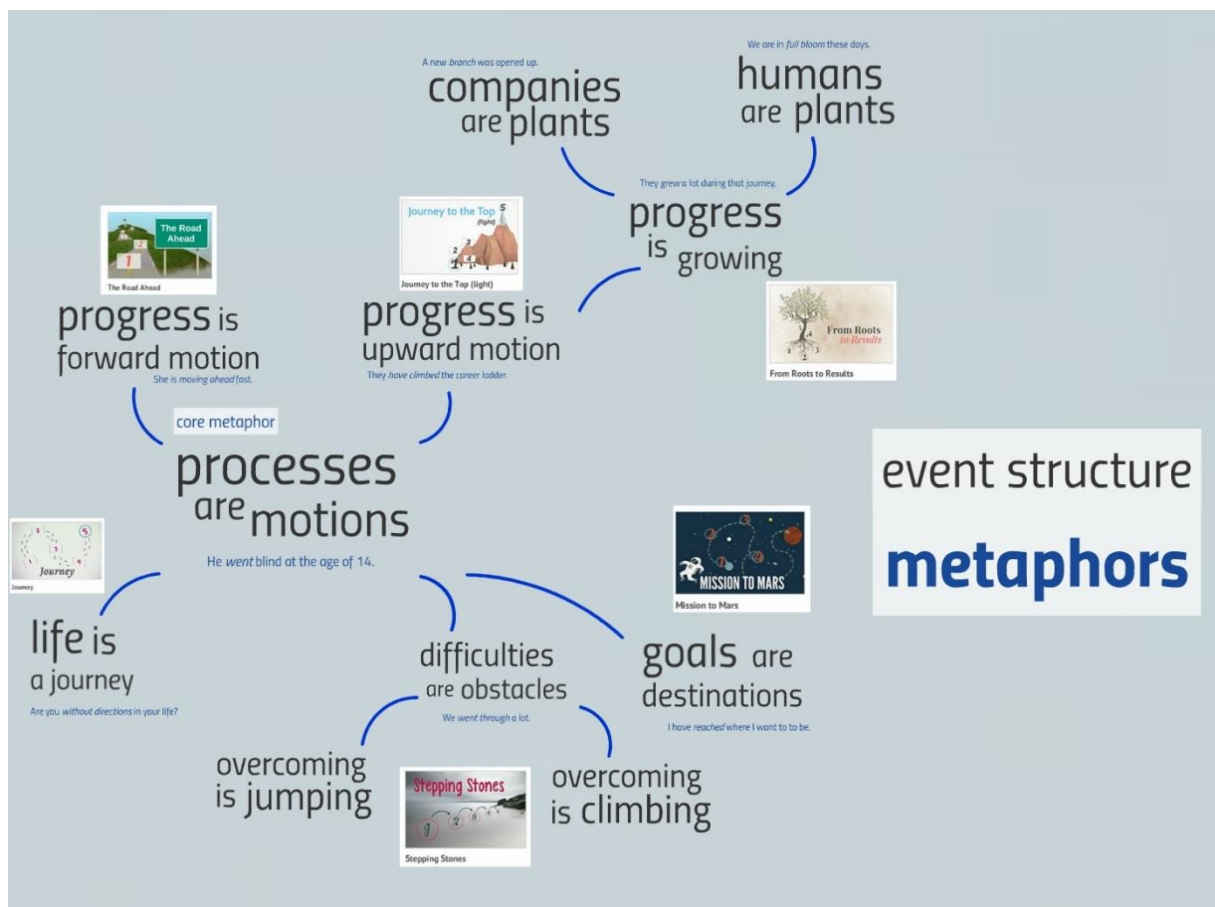


Figure 2: Event Structure metaphors in Prezi templates

Closely related to the core metaphor, we can find templates that use the PROGRESS IS FORWARD MOTION metaphor as their frames. *She is **moving ahead** fast* would be a natural verbal manifestation of this conceptual metaphor. As for the template, Prezi offers a number of frames that illustrate a road where progressing with the story means physically going forward (Figure 3/1). PROGRESS IS UPWARD MOTION is another metaphor which is closely correlated. *She has **climbed** the career **ladder*** illustrates the metaphor verbally, while visual

¹⁰ G. Lakoff, "The Contemporary Theory of Metaphor", in A. Ortony (ed.), *Metaphor and Thought*, Cambridge: Cambridge University Press, 1993; N. Yu, *The Contemporary Theory of Metaphor: A Perspective from Chinese*, Amsterdam & Philadelphia: John Benjamins, 1998; Z. Kövecses, *Metaphor and Emotion: Language, Culture, and Body in Human Feeling*, Cambridge: Cambridge University Press, 2003.

examples would be templates displaying a mountain, with the storyline advancing upwards till the conclusion/peak (Figure 3/2).



Figure 3: PROGRESS IS FORWARD/UPWARD MOTION in Prezi templates

Progress, seen as upward motion, can be further specified. The metaphor PROGRESS IS GROWING came up a number of times during the analysis. Some of the templates portray plants, most typically trees or flowers, whose key feature is that they develop by growing (Figure 4). The presentation, consequently, progresses by going “from roots to fruits”. Some more specific metaphors arising from this are COMPANIES ARE PLANTS and PEOPLE ARE PLANTS (*A new **branch** opened up* and *We are in **full bloom** these days*); that is, these templates can be used for storytelling, and more specifically, to describe events of companies and people.



Figure 4: PROGRESS IS GROWING in Prezi templates

The often quoted LIFE IS A JOURNEY pops up just as frequently on Prezi templates as in verbal communication. It is so because we tend to talk about life in terms of journeys. The basis of the LIFE IS A JOURNEY conceptual metaphor is the correlation of bodily experiences between one’s journeys and one’s life. The experience of being in motion and on a journey, which are inseparable parts of our lives, can be perceived to have a similar structure with the experience of living. The two domains share numerous fundamental correspondences.¹¹

¹¹ Z. Kövecses, *Metaphor: A Practical Introduction*, New York: Oxford University Press, 2002.

JOURNEY	LIFE
traveler	person
co-travelers	partners
obstacles	difficulties
crossroads	choices
destinations	goals
etc.	etc.

To translate this into visual frames, the related templates display some kind of a road or a path, furnished with a certain number of stops (Figure 5/1). Or, when the focus is on the obstacles, the road is made up of stepping stones for example, which the traveler/storyteller needs to overcome one by one (Figure 5/2). If, however, we want to highlight neither the process nor the difficulties of the journey but its goal, then the destination, like Mars, gets the visual-verbal emphasis (Figure 5/3).



Figure 5: LIFE IS A JOURNEY, DIFFICULTIES ARE OBSTACLES, and GOALS ARE DESTINATIONS in Prezi templates

Having identified obvious metaphorical trends in its manifesto, it is now confirmed that Prezi seems to be a metaphorical communication tool even in practice. After the analysis of its user interface, focusing on the templates offered to users when starting a prezi, we have seen that in 20 out of 92 of the templates the framing *is* metaphorical. Several manifestations of the Event Structure Metaphor System can be tracked on the templates, like PROGRESS IS FORWARD MOTION, PROGRESS IS GROWING or LIFE IS A JOURNEY. Hypothesis 1, namely that Prezi offers a metaphorical tool, proved right.

Users Matter¹²

After an investigation into Prezi's website, inspecting how the company sees its software, and into Prezi's user interface, exploring what users are offered to work with, it is time now to screen how users actually use Prezi. We have observed that the software's functioning is based on spatial metaphors, thus, upholding Hypothesis 1. Now we need to examine if and how users make use of this feature, in order to test Hypothesis 2, metaphoricity in Prezi being one reason for Prezi's success or not.

For the analysis of user behaviour, I have adopted materials the company made accessible for me for research reasons. First, I got hold of statistical information on the most popular templates, broken down into regions (Europe, North America, etc.). Secondly, I

¹² The research presented in this chapter could not have been done without the kind assistance of Zsuzsa Kovács, Viktor Nagy, and Gábor Vályi, to whom I am grateful.

received the same information about templates I had defined as metaphorical. From these stats, I intended to reveal the popularity and usefulness of (metaphor-based) templates. The third source of information was a database of “random prezis” made with specific templates. In other words, I had access to researching not only how popular a given template seems to be among global users but also how that specific template is translated into prezis. I was specifically interested to see how much metaphors play a role and how frame and content work together.

The analysis brought surprising results. There was one template in the list that overpowered all others. To my astonishment, it was the blank. 30% of all prezis are made without any template design (the stats hold both globally and regionally). All the other templates had altogether insignificantly low percentages (only 1. ...% or 0. ...%). This means that the templates are approximately equally used, with no preference given to metaphorical ones. When I went to discuss my findings with the company’s chief UX researcher, she explained to me that it is no surprise I find the data strange. She said these statistics are “noisy” and the company does not even use them. What is to be considered as “accurate result” is that the most popular choice is the blank. Nevertheless, what comes after depends on how Prezi arranges the templates; thus, not on user preference.

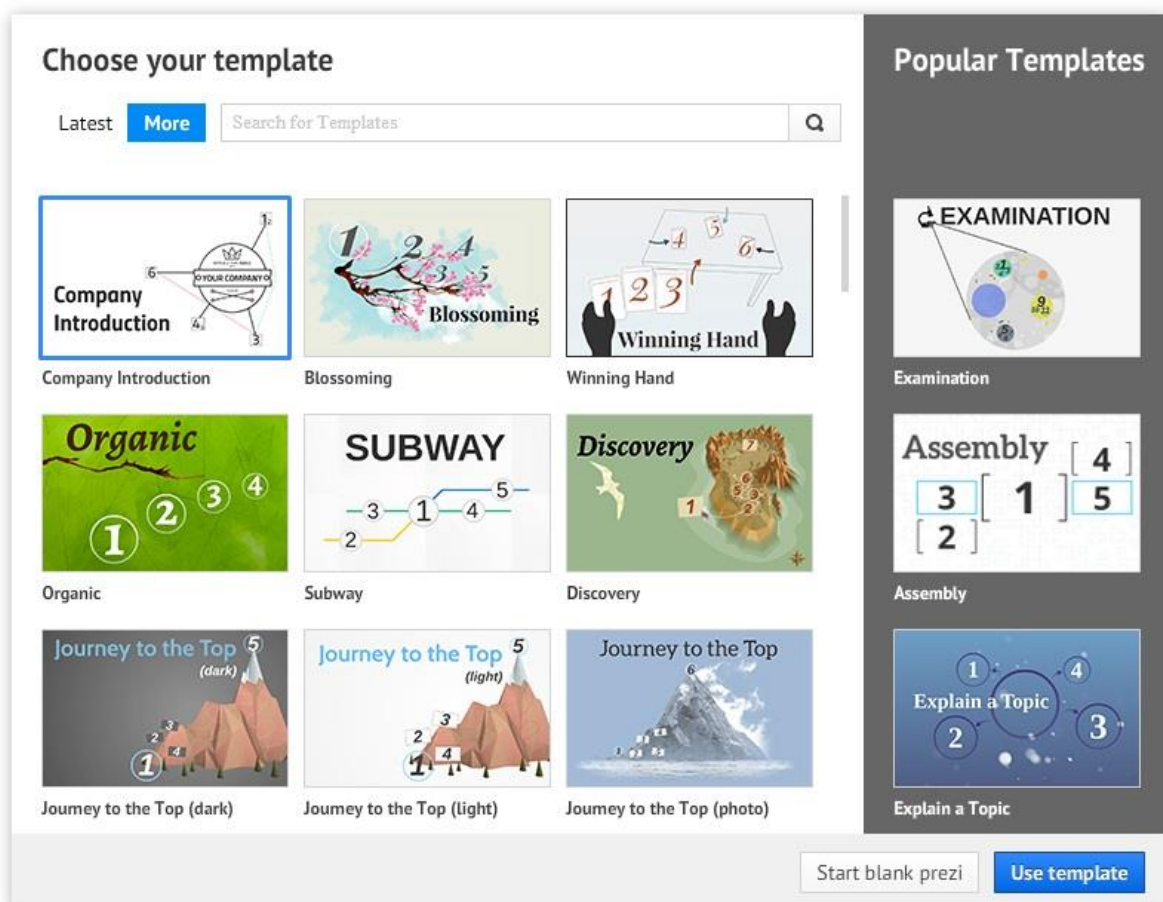


Figure 6: Template arrangement on Prezi’s user interface

We need to go back for a moment to the user interface, so we can observe the arrangement of templates. After a closer look, we realize that templates are divided into 3 sections. On the left, under “Latest”, we see 9 templates. On the right, with highlighted background colour, we have 3 templates labeled as “Popular”. These are the templates that appear on the first page; consequently, many users encounter only these, and not the 80 other, which are one click away (under the “More” button, as seen on Figure 6).

We would be tempted to think that whatever is categorized under the labels “Latest” and “Popular” are really the latest and the popular (thus, relevant data for our research). It turns out, however, that the reason why these templates are displayed on the front page and pushed for the consideration of users is because they are the ones the company found to be the “most successful”. These templates seemed to be the easiest to use, thus, the ones to be recommended for beginners (who will probably not notice or bother to click further).

As a consequence of Prezi’s interference with the display of templates, the popularity of a given template can hardly be determined from the available data. The importance of metaphoricity cannot be tested either.

Moving on from the quantitative analysis of statistics, we still have the qualitative examination of template use to test Hypothesis 2. I had access to randomly selected prezis made using a given template. I checked a number of presentations from each of the templates on the “Most popular” list and each of the templates on the “Metaphorical” list to have a fair sample. Firstly, I was examining if and how the template/frame and the content were related. This was interesting mostly in the case of metaphoric templates. Secondly, I also checked if there was any clear use of verbal-visual metaphors in the content.

In the majority of the cases, I found a double no. Most of the prezis did not exhibit a clear connection between the frame the template defined and the content the user added, nor did they use the metaphor offered by the template. Take for example a prezi that made use of the “Blossoming” template. Illustrated around a branch of a blossoming tree, a presentation on diabetes takes shape in front of our eyes. The coupling of the disease and the tree called for a non-literal, metaphorical reading, but the connection did not come self-evidently. Therefore, I checked for verbal anchoring, that is, for some reference in the text to ground the connection. I did not find any. While of course there is no guarantee there is not, but it remained hidden for (at least one of) the viewers. Without a perceived connection, the framing can be disturbing. Nevertheless, since this template was more low-key, calling equally for a mood, as for a specific frame, the dissonance was not too loud.

In cases when the template, of space or football for example, is more detailed and pronounced, the viewer can experience a stronger sense of disharmony, even confusion. To give an example, the SPACE frame (of the template “Mission to Mars”) was used to talk about Jennifer Lawrence, an American actress. Not only was there no reference in the text how she is related, when I did a little background study into her filmography and biography, to check if there is any info which is common knowledge, only I was not aware of, still nothing popped up. Similarly, a presentation about 3D printing was placed within the FOOTBALL frame, again with no reference to any kind of connection (Figure 7).



Figure 7: Non-metaphorical template use

In some of the cases, however, I observed a certain degree of consciousness regarding template/frame use. Even though the metaphor invoked by the template is not fully utilized in such prezis, we do identify some traces to connect content and frame, mostly in a metaphoric way. The prezi illustrated in Figure 8 contains a verbal reference to the name and design of the template in its subtitle: a *roadmap* to in-text citation. Even a one-word anchoring, which places the presentation on citations into a JOURNEY frame with a start and an end, can contribute a lot to meaning-making and understanding, which are primary goals of presentations.

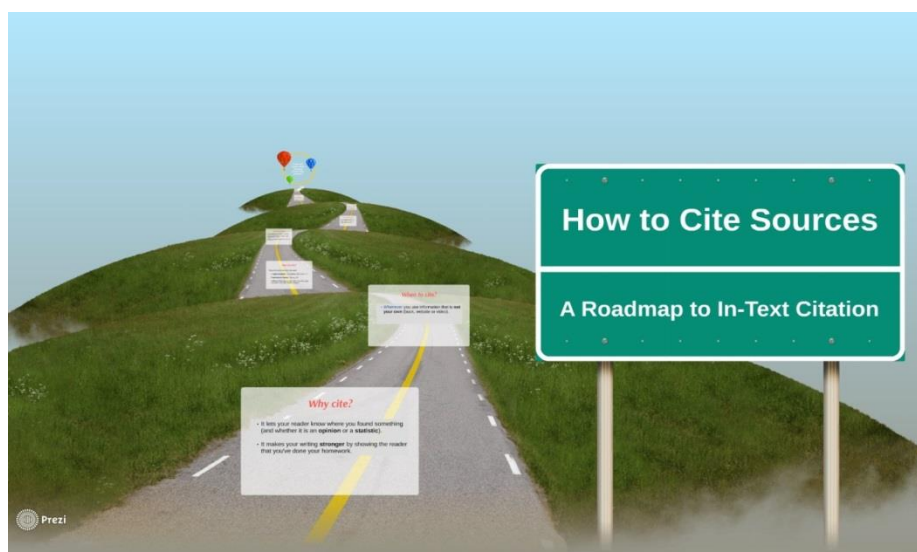


Figure 8: Slightly metaphorical template use

I found a couple of exceptional prezis, which made compelling use of the metaphoric frames arising from the template. Usually the JOURNEY frame seemed most fruitful. One prezi, for example, illustrated the Afghan folk traditions, from birth to funerals, on a road, invoking the LIFE IS A JOURNEY metaphor. Another portrayed the psychological progress of humans on a path, as if we could *walk through life*. Presentations that manage to marry verbal and visual, frame and content, often through metaphoric correlation, communicate in a more lucid and more powerful way (see Figure 9 for reference).

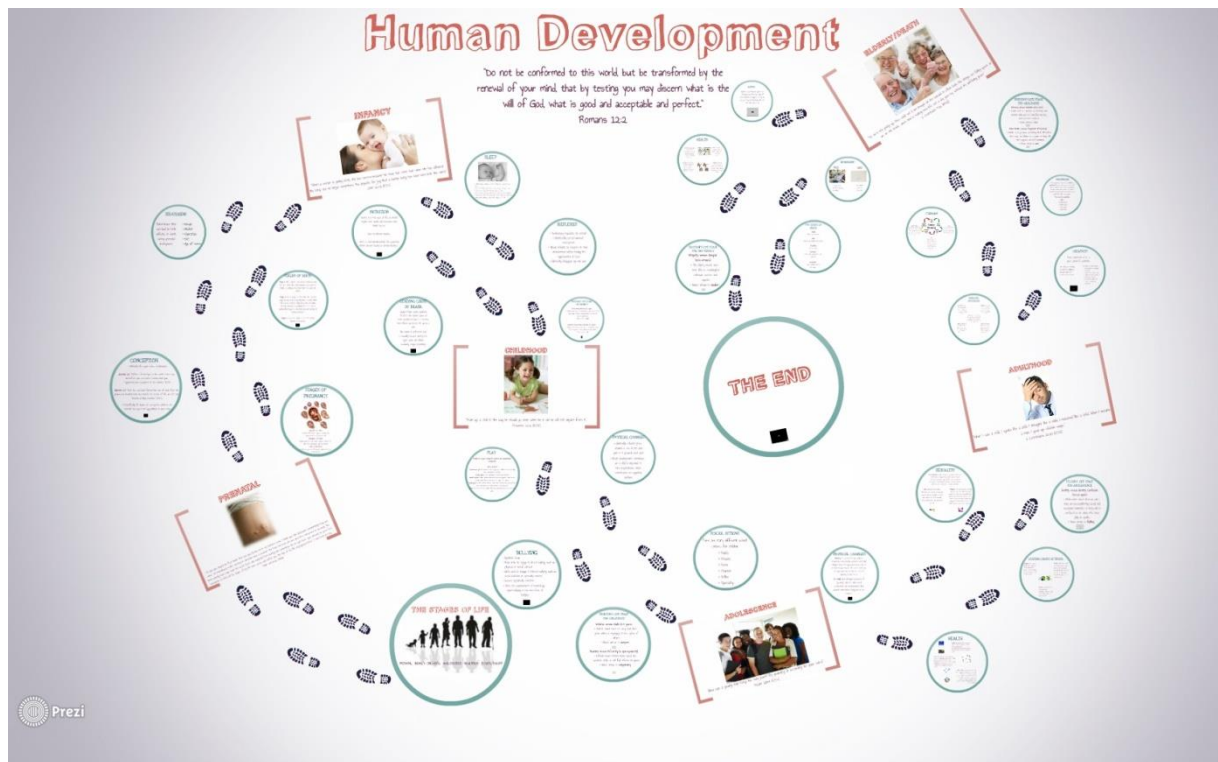


Figure 9: Metaphorical template use

The analysis of random prezis made with specific templates did not prove Hypothesis 2 right. I detected scarce sensitivity for frames and little awareness for metaphors. In the majority of the cases, the template use seems rather arbitrary. It does not appear to “add” to the content, at least not in a straightforward way, nor does the metaphor it entails get elaborated. The hypothesis that proposed that Prezi might be popular because it gives its users a metaphorical tool, which models the way they think, is clearly not defensible. Mainstream users do not seem to like and use Prezi for metaphors.

Conclusions Matter

Prezi is a presentation software that redefines space and creativity. On an endless canvas we are invited to paint our ideas like they are in our head. Put an image here, place a video over there, draw a line here because they are related, enlarge and tilt the picture, then zoom out to add captions. When we are done putting out everything we had in your head, we set the path we will guide our viewers through. Because PRESENTING IS STORYTELLING and STORYTELLING IS A JOURNEY. The scrutiny of its philosophy and the analysis of its templates revealed, Prezi is

based on spatial metaphors which pave the way to engaging and memorable communication.

Metaphor is a powerful communicative tool that we use in language, culture, and reasoning. Our thinking is fundamentally metaphoric.¹³ Therefore, Prezi gives a compelling tool in the hands of those who are willing to learn how to manoeuvre with it.

The examination of randomly selected prezis uncovers, however, that only few users take full advantage of this tool. Combining frame and content still proves to be a challenge. The scope of the analysis could not reach to non-template-based prezis or to professional (paying) users, but considering that 70% of prezis are made with templates and the majority of subscriptions is still for (free) public accounts, the results of this study appear to be representative and the conclusions to be valid.

The dividing line between a half-baked presentation and a well-done prezi is a metaphor, pervasive in our fast-paced world: TIME IS MONEY. How much *time* can you typically spare from your life to spend on making your presentation slides? If you took the time to do the research, write the paper, sit through the conference, why not give your presentation the time it needs?

Your ideas matter.

<https://prezi.com/4wqsoyppi8bj/metaphors-matter-a-visual-presentation/>

¹³ G. Lakoff and M. Johnson, *Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought*, New York: Basic Books, 1999.

KOSKIMA, Raine and FENYVESI, Kristóf

A MISSION IMPOSSIBLE? LEARNING THE LOGIC OF SPACE WITH IMPOSSIBLE FIGURES IN EXPERIENCE-BASED MATHEMATICS EDUCATION

Introduction

Creating visual illusions, paradox structures and ‘impossible’ figures through playful and artistic procedures, holds an exciting pedagogical opportunity for raising students’ interest towards mathematics and natural sciences and technical aspects of visual arts. The *Experience Workshop International Math-Art Movement* (EWM)¹ has a number of pedagogical methods, which are connected to visual learning, including visual paradoxes and perspective illusions.

EWM started in 2008 at the *Ars Geometrica Conferences* (2007–2010, Hungary) as a collaborative effort of mathematicians, artists, and teachers of mathematics and the arts. In the open network of the EWM almost two hundred scholars, artists, teachers of various subjects, craftsmen and toymakers experiment with various new educational methods and approaches to develop interactive and play-oriented combinations of mathematics and arts. EWM organizes math-art festivals, workshops, exhibitions for children and their parents, trainings and conferences for teachers and professionals interested in experience-based mathematics education.

EWM’s math-art workshops are based on the active and creative manual participation of the students. EWM’s programs include such experimental, practical workshops in playful forms that rely on mathematical connections in the arts which exceed the mathematics curricula taught in ordinary schools.

There are several visual artists, teachers, and mathematicians in the EWM’s community who work on visual paradoxes and their pedagogical implementation in the experience-based education of mathematics. There are digital games as well which employ visual illusions as a part of their game mechanics. Most of these games were not designed as an educational game, but they may be used for educational purposes, to clarify mathematical concepts behind and related to visual illusions (symmetry, perspective, isometric projection etc.), much in the same way as the EWM approaches. In this article we will briefly introduce an EWM workshop related to impossible figures and analyze which characteristics of certain digital games based on visual illusions can contribute to the pedagogic impact, and how to best take advantage of them.

Math-Art Workshops Inside and Beyond the Classroom

In EWM’s programs, the pupils can become acquainted with mathematical and artistic procedures through various math-art educational tools and art-related games developed originally by EWM members. EWM events feature programs with topics like planar and spatial tessellations; collaborative construction of complex spatial structures (e.g., 3D

¹ Homepage: www.experienceworkshop.hu, last accessed 06. 02. 2015.

projections of multidimensional objects²) with ZomeTool, 4dFrame, and other math-art toolkits. EWM has a wide selection of educational tools and a large international collection of mathematical art to develop e.g. the playful recognition of symmetries and other skills based on systems thinking; EWM also provides many ways to demonstrate non-Euclidean geometries with the help, among others, of Lénárt-spheres; Möbius strips, self-similar fractals; artworks of Escher,³ Vasarely,⁴ and so on; movement and dancing, experiments with musical instruments, etc. (cf. Figure 1).

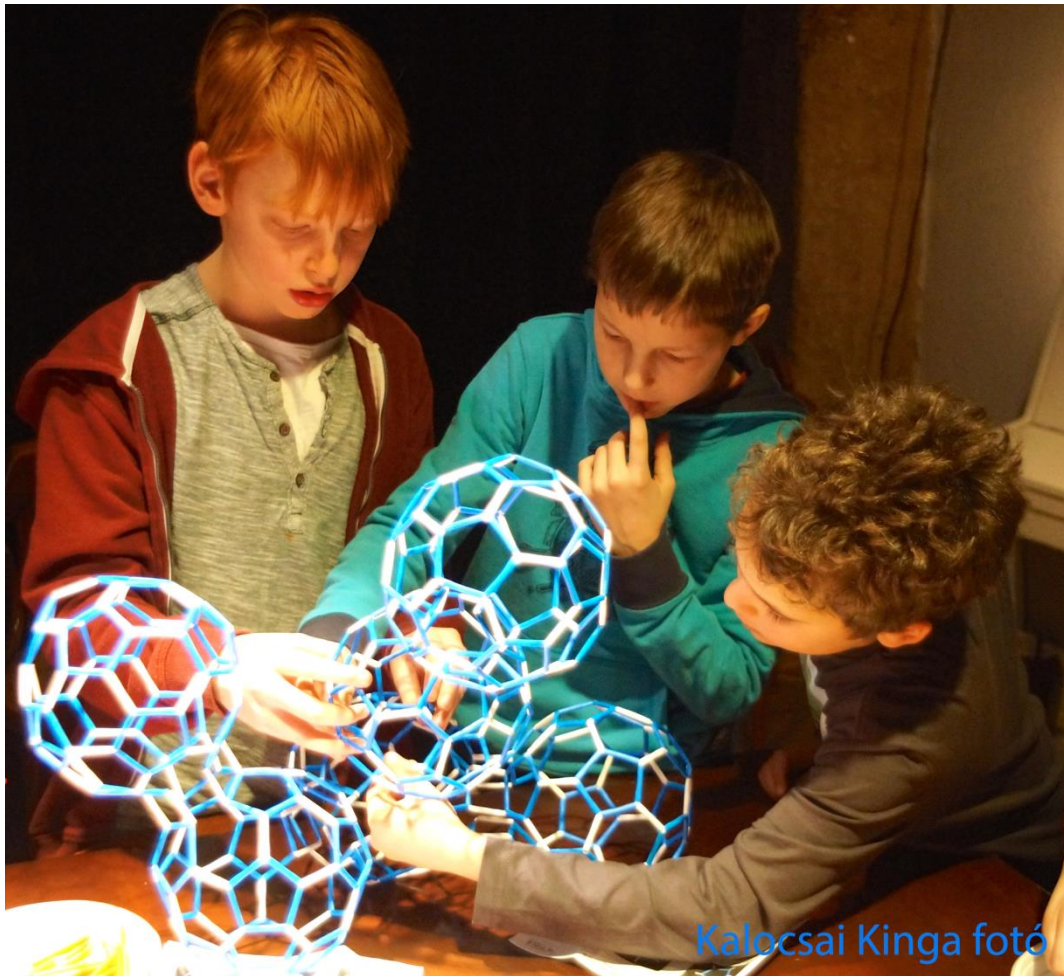


Figure 1: Collaborative work with 4Dframe kit at an Experience Workshop event.
Photo: Kinga Kalocsai

Impossible Figures and the Power of Visual Paradoxes: an Example from Experience Workshop's Repertoire

² Sándor Kabai et al., "Experience-workshop in mathematics and space education: joyful teaching program in Hungary", *43rd Lunar and Planetary Science Conference*, #2611, LPI, Houston, 2012.

³ György Darvas and Kristóf Fenyvesi, "Symmetries in Action! The Hungarian Experience Workshop Movement in the Education of Mathematics and Symmetry Studies through Arts", *Proceedings of the 12th International Conference of the Mathematics Education into the 21st Century Project*, Alan Rogerson, ed., Herceg Novi, Montenegro, 2014; György Darvas, "Preface", *Catalogue of Tamás F. Farkas*, Budapest: Demax, 2010, pp. 2–3.

⁴ Slavik Jablan and Kristóf Fenyvesi, "The Vasarely Playhouse: Look and Combine!", *Proceedings of Bridges 2011 World Conference*, Coimbra: Tessellation Publications, 2011, pp. 633–636.

According to Margo Kondratieva, paradoxes, and especially visual paradoxes, are potentially useful for teaching mathematics due to their engaging power and the effect of surprise.⁵ Kondratieva also sees visual paradoxes as highly useful in classroom as they can be easily implemented as exercises where the pupils can experiment with alternative solutions through drawing or manipulating cut-out shapes. Similarly to EWM's approach, Kondratieva emphasizes the importance of hands-on activities: "Manipulations with physical models and figures of geometrical objects allow learners to get a better understanding through reorganization of the perceived information and construction of an appropriate structural skeleton for a corresponding mental model."⁶

Even though there are clear benefits in this sort of visual experimentation, it is equally evident that the power of visual reasoning is restricted in some aspects. For example, negative and complex numbers cannot be dealt with and are excluded as topics. This limitation may, at least to some extent, be overcome when physical objects are replaced by manipulating virtual objects in digital environments. Another limitation is the reliability of visual images: we cannot necessarily always rely on our own eyes, as various well known visual illusions make this evident. Visual illusions and paradoxes, however, may be turned into means of engagement, and pedagogical tools in themselves.

The key in the visual approach is to foster an easy and fast way to try out several alternative solutions to the given problem: "the point of the exercise is to make a large number of observations, to learn how to make a picture talk to you about its properties, to retrieve the information compressed in a drawing".⁷

A special group of visual paradoxes and illusions, namely impossible figures, are apparently enjoying special interest and are receiving special attention in the EWM's community. Artists Tamás F. Farkas and István Orosz create impossible figures as a part of their artistic oeuvre, Ildikó Szabó, a mathematics teacher, develops a math-art education program based on Farkas' and Orosz's artworks, and the mathematician László Vörös carries out geometrical research connected to Farkas' and Orosz' art pieces.

Bruno Ernst defined impossible figures as figures which can be imagined or drawn, but which cannot be made in any concrete form.⁸ Their effect is based on (at least) two separate layers of illusion. As Ernst summarizes, the first layer is the illusion of spatiality: all we are really looking at is a set of lines printed on a piece of paper (flat), yet we appear to see a solid object. And the second layer is the illusion of continuity: the bars which make up an impossible tri-bar cannot meet in real space (different perspectives united in an isometric drawing), but we still try to assign a meaning.⁹ There are several noted examples of impossible figures from the fine arts, certainly the most famous ones are the Dutch artist M.

⁵ Margo Kondratieva, "Understanding mathematics through resolution of paradoxes", *Mediterranean Journal for Research in Mathematics Education*, 6 (2007), pp. 127–138; Margo Kondratieva, "Geometrical Sophisms and Understanding of Mathematical Proofs", *Proceedings of the ICMI Study 19 conference: Proof and Proving in Mathematics Education*, Fou-Lai Lin et al., eds., vol 2. The Department of Mathematics, National Taiwan Normal University Taipei, Taiwan, 2009, pp. 3–8.

⁶ Margo Kondratieva, "Geometrical Sophisms and Understanding of Mathematical Proofs", *Proceedings of the ICMI Study 19 conference: Proof and Proving in Mathematics Education*, Fou-Lai Lin et al., eds., vol 2. The Department of Mathematics, National Taiwan Normal University Taipei, Taiwan, 2009, p. 4.

⁷ Margo Kondratieva, "Geometrical Sophisms and Understanding of Mathematical Proofs", *Proceedings of the ICMI Study 19 conference: Proof and Proving in Mathematics Education*, Fou-Lai Lin et al., eds., vol 2. The Department of Mathematics, National Taiwan Normal University Taipei, Taiwan, 2009, p. 5.

⁸ Bruno Ernst, *Adventures with Impossible Figures*, Tarquin Publications, 1986.

⁹ Bruno Ernst, *Adventures with Impossible Figures*, Tarquin Publications, 1986, pp. 10–15.

C. Escher's *Belvedere* (1958), *Ascending and Descending* (1960), and *Waterfall* (1961), and the phenomenon is equally fascinating and challenging to psychologists and mathematicians.

Impossible figures were first described scientifically by psychiatrist Lionel Penrose and his son, the later world famous mathematical physicist, Roger Penrose, in their paper: "Impossible Objects: A Special Type of Visual Illusion", published in the *British Journal of Psychology* in 1958. The paper included illustrations such as the impossible triangle and the impossible steps (Figures 2 and 3), both of which were also used by both the Swedish painter Oscar Reutersvärd and M. C. Escher in their works.

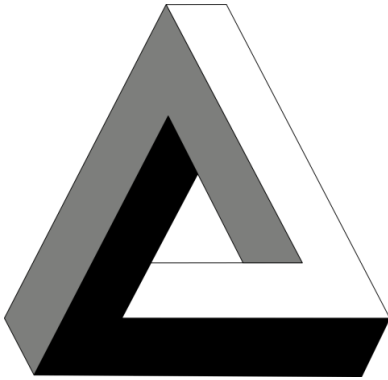


Figure 2: Penrose's impossible triangle

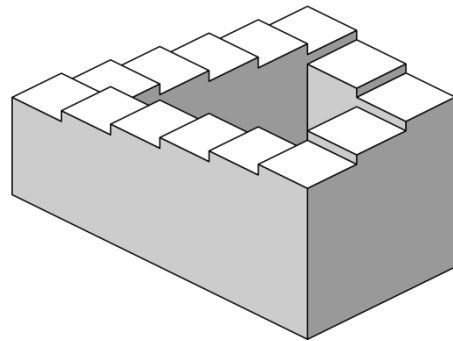


Figure 3: Penrose's impossible steps

In the case of impossible figures, a specific correspondence develops between the two- and three-dimensional space. Therefore studying or drawing these figures can play an important role in visual art studies as well as in mathematics education. Studying impossible figures not only helps in thinking creatively but it also improves depth perception. Furthermore, getting acquainted with impossible objects can open the way to understanding higher (more than 3) dimensional spaces and high-dimensional structures within them.



Figure 4: *Tamás F. Farkas's compositions with impossible figures*

At Farkas's EWM workshops, students use the artists' templates to recreate his impossible figure designs (cf. Figure 4). The templates are based on the connection between the structural properties of impossible figures and tessellations with special modules, called Necker or Koffka cubes. The Necker cube is an optical illusion of perceptual inversion first published as a rhomboid in 1832 by Swiss crystallographer Louis Albert Necker. Some decades later, the German psychologist Kurt Koffka, one of the founders of Gestalt psychology re-discovered reversible figures like the Necker Cube, as a part of his experiments on problem-solving and creativity. As EWM's leading expert of visual mathematics, Slavik Jablan writes in his seminal article "Modularity in Art", Necker or Koffka Cubes are "multi-ambiguous" objects: "they can be interpreted as three rhombuses with joint vertex, as convex or concave trihedron, or as a cube. If we accept its 'natural' 3D interpretation — a cube — then for a viewer there are three possible positions in space: upper, lower left, and lower right, having equal right to be a point of view. So, for the corresponding three directions, a Koffka cube represents a turning point. Having such multiple symmetry, it fully satisfies the conditions to be a suitable basic modular element." Jablan also calls attention to the connection between the Koffka cube and Thiery-figures (proposed at the end of 19th century) consisting of two Koffka cubes, Reuteswärd's impossible objects, the Penrose tribar (Figure 5), and artworks by Victor Vasarely (Figure 6), among other examples. All of them could be derived as modular structures from a Koffka cube, as "from Koffka cubes we could construct an infinite family of impossible figures. In the process of their growing, in every point, we have a possibility to proceed in three

directions, i.e. to choose each from six oriented ways”¹⁰ and exactly this is the underlying principle of Farkas’s impossible designs.

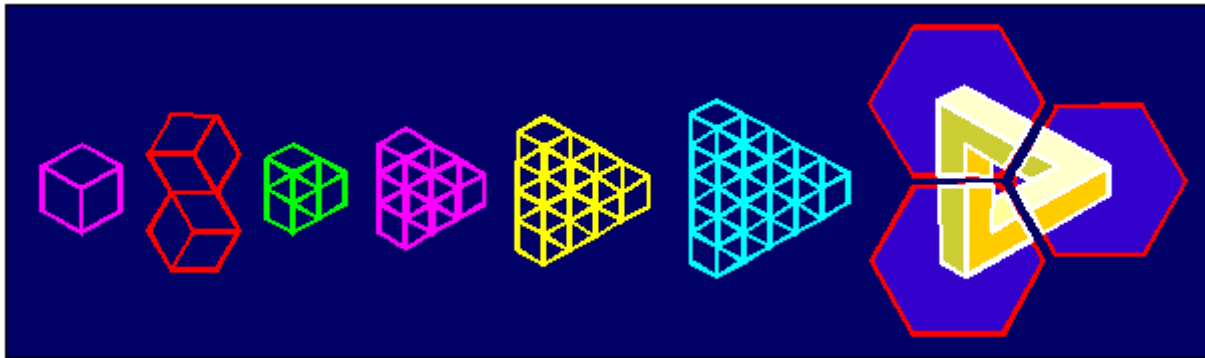


Figure 5: The “evolution” of the Penrose tri-bar from tessellated Koffka cubes.
Source: Jablan.

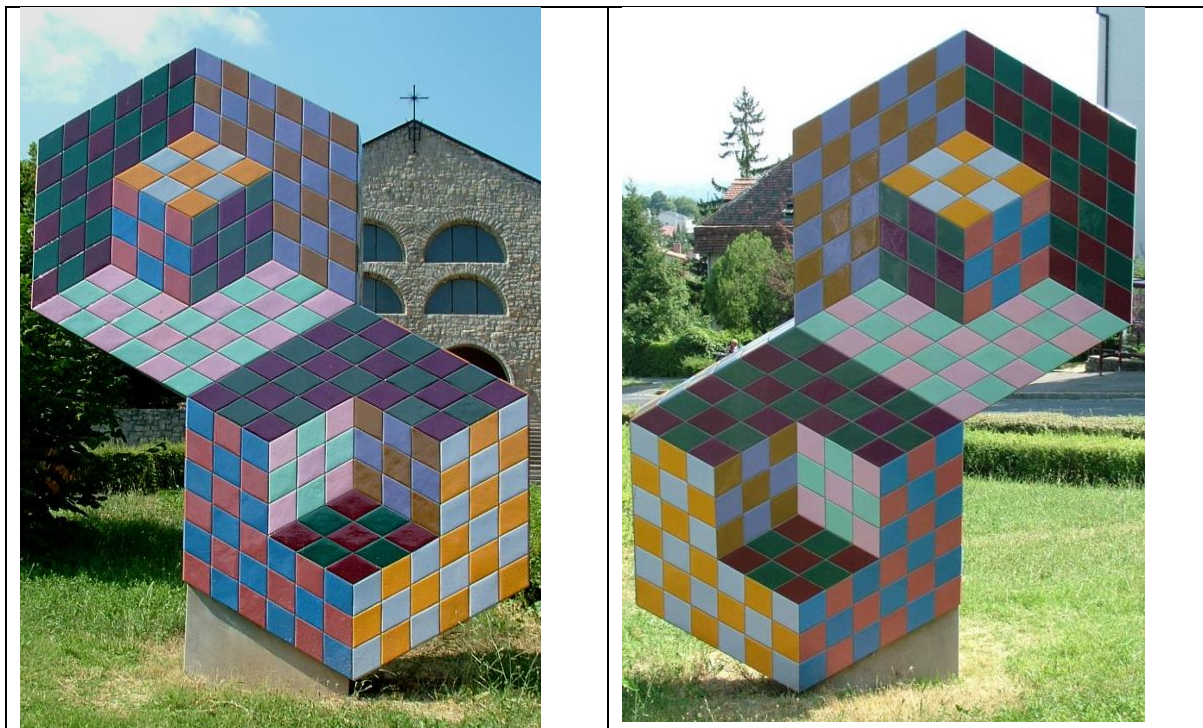


Figure 6: Koffka cubes on Victor Vasarely’s JEL sculpture.
(Pécs, Hungary, 1977)

F. Farkas’s workshop starts with the deep study of his impossible artworks and a free discussion on their gradually discovered geometrical properties. Then each student chooses a figure which they would like to re-create.

¹⁰ Slavik V. Jablan, “Modularity in Art”, *Modularity: Understanding the Development and Evolution of Natural Complex Systems*, Werner Callebaut and Diego Rasskin-Gutman, eds., Cambridge, MA: MIT Press, 2005, pp. 259–282, cf. esp. pp. 263–264.

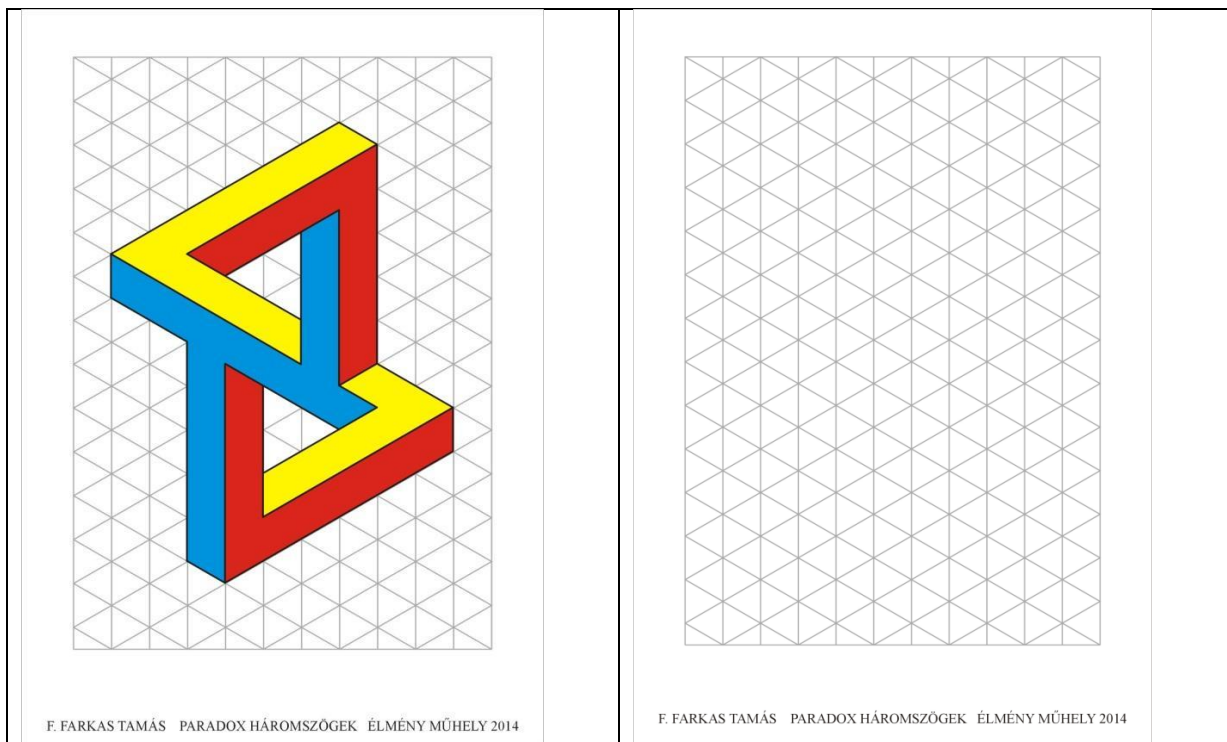


Figure 7: Tamás F. Farkas's templates for creating impossible figures with students. Template A (left), Template B (right). The two Penrose tri-bars of the composition on Template A are diagonally symmetric.

Copies of templates A and B belonging to the given artwork are printed according to the number of participating students (cf. Figure 7). The figure on template A is cut into parts along the black line bordering elements with a pair of scissors. Afterwards, the students' task is to recompose the figure on the raster net B belonging to the given form. The facilitator of the activity might draw the participants' attention to the fact that two elements of the same colour cannot border each other (cf. Figure 8). After completing a figure the participants give a verbal description of the object, defining their specific geometric features and discussing observations obtained during the construction together. The raster net B can also be used by students to draw the figure as well. After becoming familiar with the geometric features of impossible objects, students try to design their own impossible objects on the raster net B, by implementing their geometrical knowledge, developed at the workshop.



Figure 8: Building a “Koffka” pyramid as an introductory exercise in the Impossible Figures workshop with lower primary school pupils in F. Farkas Tamás’s workshop in Experience Workshop — International Movement of Experience-Centred Mathematics Education (www.experienceworkshop.hu) event at ANK School in Pécs.

Photo: Csaba József Szabó.

The experience-centered process of exploratory introduction to geometry problems related to impossible figures can be successfully supported by using Dynamic Geometry Softwares (DGS) such as the free-access GeoGebra (www.geogebra.org) to extend investigations and foster deeper understanding of impossible figures’ geometrical properties. GeoGebra is accessible, engaging, encourages students to further explore the geometrical situation, and provides opportunities for making and evaluating conjectures of geometrical results. Students can construct the image of Farkas’s impossible figures in GeoGebra and be used to study such questions as e.g. how many different shapes can be seen in the image (different colours, but same shapes not to be regarded as different)? What transformations have to be applied to re-create a figure from single modules? What kind of symmetries can you identify in each figure? etc.

Digital Games in Mathematics Education

Mathematics educational games (mathgames) are another option to introduce experiential approaches to mathematics teaching. They differ from the exercises described in the previous section in that they do not involve such hands-on connection to physical materials, but provide experiential practices through manipulation of virtual objects and environments (the similarity of educational computer games and hands-on approaches has been emphasized by, amongst others, Squire¹¹). Games are employed in mathematics classrooms

¹¹ Kurt Squire, “Changing The Game: What Happens When Video Games Enter the Classroom?”, *Innovate: Journal of Online Education*, 1(6), 2005, p. 5.

in various ways and to various extents. The main ways to employ games are, as Bragg sums it up:¹²

As reward for early finishers. This has not much to do with teaching mathematics, as the reward games are not necessarily even related to mathematics contentwise. The practice of letting pupils to play games as a reward, however, reflects the desirability of game play amongst them.

To enhance students' attitudes toward maths. This approach is directly related to the topic of this paper. There is a perceived situation of pupils not liking mathematics as a subject, and games as pedagogical means are considered to improve that attitude. The results are not necessarily always positive, neither what comes to improving the attitudes, nor the learning outcomes.

In repetitive practices such as learning arithmetical computation. One of the peculiarities of games is how they manage to create a symbolic reward system which is enough to lure the players in endless repetitive trial and error cycles. Even though the games are often highly frustrating (and in some cases even intentionally so) the prospective progression to a new game level builds motivation to go through the 'grinding'. This is exactly what is required in many computation tasks, and games like Ekapeli¹³ – a renowned Finnish education game for improving reading and calculating skills – are building on that feature. (Ekapeli is targeted especially for kids with dyscalculia, which puts extra demands for keeping up the motivation, and there is an elaborate system making the game adapt to player's individual skill level).

Mathgames, however, are used clearly less to teach problem solving and creative thinking in classrooms. As Kim and Chang have stated: "Although there is overall support for the idea that games have a positive effect on affective aspects of learning, there have been mixed research results regarding the role of games in promoting cognitive gains and academic achievement."¹⁴

There are many games, both educational as well as entertainment ones, with potential in this field. Here we discuss only three of them, *The Bridge* (by Ty Taylor and Mario Castañeda, 2013), and *The Monument Valley* (ustwogames, 2014), which are both based on Escherian visual paradoxes, and *Miegakure* (by Marc Ten Bosch, forthcoming), which takes place in a four-dimensional world. They all belong to the category of independent games, which means they are commercially distributed but produced by small teams of a few developers.

In this article we discuss only two ways to employ games for facilitating visual learning of mathematics here: (1) the use of visual paradoxes as game mechanic to facilitate proof construction in the case of *The Monument Valley* and *The Bridge*, and (2) the use of simulated game world in making a non-intuitive phenomenon such as four-dimensionality better graspable, in the case of *Miegakure*. These approaches are in line with the opinion of one of the most prominent proponents of educational use of games, James Paul Gee, who emphasizes the fundamental similarities between scientific simulations and the structure of games in general.¹⁵ Whereas digital games may lack some in the concreteness of the manipulation, they make the exploration of the situation and its specific characteristics even

¹² L. Bragg, "Students' conflicting attitudes towards games as a vehicle for learning mathematics: A methodological dilemma", *Mathematics Education Research Journal*, vol. 19, no. 1 (2007), pp. 29–44.

¹³ Ekapeli's website: <http://www.lukimat.fi/lukeminen/materiaalit/ekapeli/ekapeli-in-english-1>, last accessed 06. 02. 2015.

¹⁴ S. Kim and M. Chang, "Computer Games for the Math Achievement of Diverse Students" *Educational Technology & Society*, vol. 13, no. 3, (2010), pp. 224–232, cf. esp. p. 225.

¹⁵ James Paul Gee, "Why Are Video Games Good For Learning?", 2005, <http://www.academiccolab.org/resources/documents/MacArthur.pdf>, p. 3, last accessed 18.12.2014.

more easy and engaging, thus helping the pupil to build a strong understanding of the problem in much the same vein Gee is describing under his notion of “performance before competence” in regards to educational gaming.¹⁶

Visual Paradoxes as Game Mechanic

Games like *The Monument Valley* and *The Bridge* (see Figures 9 and 10) pose challenges based on visual paradoxes. The player frequently faces situations, where proceeding is apparently blocked. There are pathways abruptly ending, staircases leading to solid walls, and targets placed on such positions where no path exists. In order to proceed, the player has first to identify potential paradoxical structures. The player has to observe the game environment and decide which elements are the most promising to offer the needed scaffolding. Then, the player has to experiment with the options provided by the game interface in order to find a way to manipulate the game world successfully. It is usually considered as bad game design, if the player has to recede to the strategy of going through all available options more or less systemically, in order to eventually stumbling into the right solution, but from educational perspective even this kind of mechanical approach bears merit in helping the player to see the different aspects of the visual presentation. When the design is successful, the initial proceeding by surprises-through-mechanic-selections gives increasingly way to proceeding-through-reasoning when the player grasps the logic of the particular visual paradoxes employed in the game.

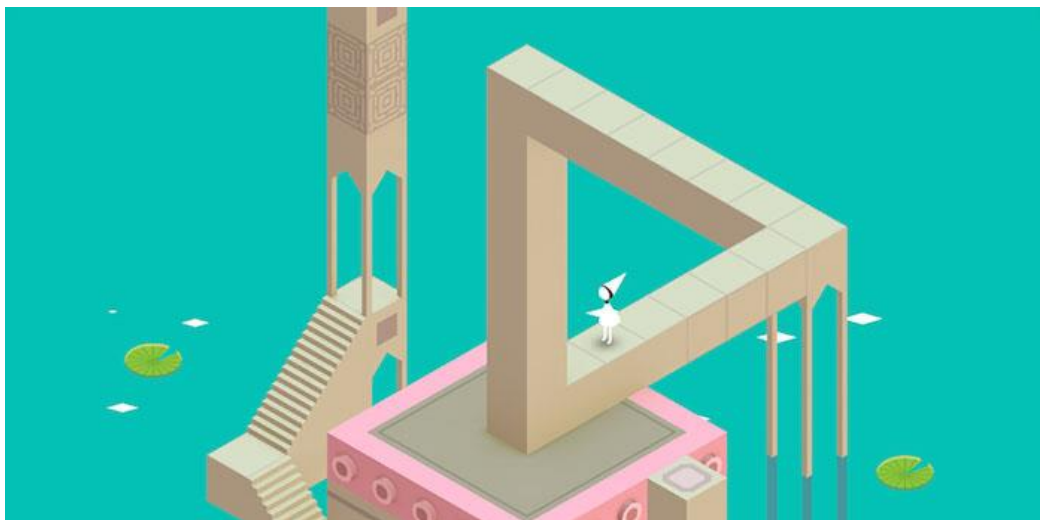


Figure 9: A scene with Penrose triangle in *The Monument Valley*. Source: Ustwo games.

When the player experiments with game environment, she builds up her understanding of the problem, or, as Kondratieva formulates it, she is “making large number of observations, making the ‘picture talk’”, as she is “search[ing] for the flaw in the initial understanding of the situation”. Intuition often helps in choosing the most promising directions in the initial phases of problem solving, but it is the very nature of visual paradoxes (as of paradoxes in general) that they are counter-intuitive. The process of going through a number of various alternatives in a systematic way, not precluding any alternatives but experimenting also with attempts that by first sight seem simply impossible,

¹⁶ James Paul Gee, “Why Are Video Games Good For Learning?”, 2005, <http://www.academiccolab.org/resources/documents/MacArthur.pdf>, p. 13, last accessed 18.12.2014.

bears two kinds of pedagogical potential. First, it is a way to build up an understanding of how a particular visual paradox is created, but even more importantly, it helps to build up a wholly new understanding of the world surrounding us, forcing first to reject the naturalistic assumptions and then expanding the pupil's skills to the extent that the solution can be found purely through reasoning. When this point is reached, the step necessary for deductive process is considerably eased: "...visual paradoxes helped students to develop a sense of the purpose of proofs by examining the links between the given information and the conclusion – the core of any deductive process. Their ability to understand and validate logical arguments was enhanced by the search for a flaw in the reasoning leading to a false conclusion."¹⁷

Thus, the game helps pupils to understand the particular problem, and consequently, to construct a corresponding mental model making it easier to understand how the formal proof is constructed. The game as such, however, does not teach the construction of formal proof itself, but this is still done by the teacher. The math games still face the same challenge as algebraic tiles and other such experiential materials, in that they should be properly embedded in classroom teaching in order to gain their full pedagogical potential. The games discussed in this section are not addressing any clear-cut topic in math curricula, which poses more requirements for the teachers in recognizing their usefulness in teaching specific topics. It is, then, a question of teacher education to provide capabilities to both recognize the pedagogical potential of non-educational games, and to implement them in the classroom teaching.

The game play in *The Bridge* is much more challenging than in *The Monument Valley*, and in addition to the purely logical puzzles of figuring out the visual paradoxes, the game requires also motoric skills and dexterity from the player. Using a game like *The Bridge* in classroom is clearly more challenging, in that it probably is not suitable for all pupils in any given class. On the other hand, with more engaging and demanding game play it may function better with avid digital game players.



Figure 10: A scene from *The Bridge*. Source: Ty Taylor and Mario Castañeda.

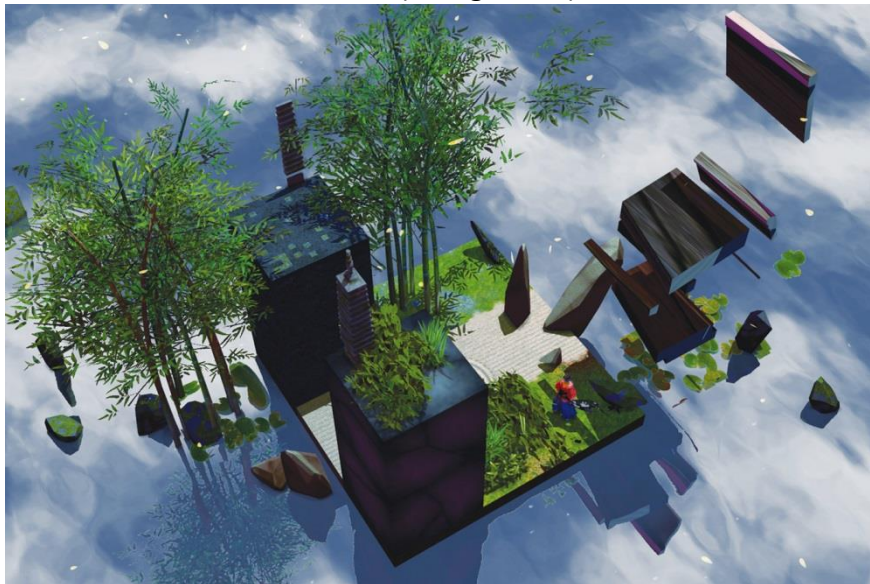
A Game for Learning the Logic of a Four-Dimensional Space

¹⁷ Margo Kondratieva, "Geometrical Sophisms and Understanding of Mathematical Proofs", *Proceedings of the ICMI Study 19 conference: Proof and Proving in Mathematics Education*, Fou-Lai Lin et al., eds., vol 2. The Department of Mathematics, National Taiwan Normal University Taipei, Taiwan, 2009, p. 8.

Miegakure is a game which takes place in a four-dimensional space. The graphics engine uses a four-coordinate system for each game position but, as it is not possible to present four spatial dimensions, the player sees a three dimensional projection of the four dimensional world. Moving around in a four dimensional space using three dimensional projection is tricky and highly counter-intuitive. In this sort of environment “puzzles happen naturally: they are just simple consequences of 4D space”, as the game designer Ten Bosch has stated in an interview.¹⁸

Miegakure is not primarily intended as an educational game, but there is a strong educational aspect in it, as evidenced by the designer: “Ever since people discovered the concept of a fourth dimension of space around a century and a half ago, they have tried to come up with what would be possible if space was actually four-dimensional. Walking »through« walls would be one of the simplest consequences of being able to move in 4D space. But what would it actually look like? *It's not often that watching a video-game trailer actually teaches you about real math.*”¹⁹

The higher dimensions challenge our intuitive notion of space and *Miegakure* provides a way to better make sense of such abstract concept. Even though it is not technically that difficult to make the calculations required for three dimensional projection of four dimensional space, the amount of calculations required to project areas with details in them quickly grows high. Furthermore, to really be able to investigate the four dimensional space, one has to constantly shift her perspective, resulting in even more calculations, as each shift changes the projected “three dimensional slice”. It is hard to fathom such hand-on experiment which would let the pupil experiment with three dimensional projections of four dimensional space as easily and in such an engaging way as this sort of game. *Miegakure* exemplifies how, in Gee’s words “the player must recognize problems and solve them from within the inside of the simulated world”²⁰ (cf. Figure 11).



¹⁸ Beckett Mufson, “This Man Is Using Math To Create An Impossible 4D Video Game”, The Creators Project Blog, <http://thecreatorsproject.vice.com/blog/impossible-4d-puzzle-game-defies-physics-and-lets-you-walk-through-walls> (2014), last accessed 02.12.2014.

¹⁹ Marc Ten Bosch, “New Trailer: How to walk through walls using the 4th Dimension”, Marc Ten Bosch Blog, 2014, <http://marctenbosch.com/news/2014/08>, last accessed 2.12.2014, emphasis in original.

²⁰ James Paul Gee, “Why Are Video Games Good For Learning?”, 2005, <http://www.academiccolab.org/resources/documents/MacArthur.pdf>, p. 3, last accessed 18.12.2014.

Figure 11: A scene from *Miegakure*. Source: miegakure.com.

Miegakure shows one way how a certain mental model may be brought from purely computational to experiential mode, where it may be played and experimented with. Here again, however, teacher's role is central in explaining the logic behind the projections, even though the game includes also levels where the logic is demonstrated through analogy, using two dimensional projections of three dimensional space. Also, the game includes the shape of a modified 120-cell (Polydodecahedron), which is one of the four dimensional analogs of three dimensional Platonic solids, and the varying projections of this regular shape helps to understand the underlying logic.²¹

Conclusions

Elster and Ward, specialists of The Royal Conservatory of Music's *Learning Through the Arts* (LTTA) program in Toronto, Canada call the attention to the case of Escher "whose poor grades at school precluded a career in architecture, came to prominence in the 1950's when mathematicians recognized in his work an extraordinary visualization of mathematical principles, including plane and projective geometry, Euclidean geometry, and structure and mechanisms. Escher's work also embraces the notions of paradox and »impossible« figures, giving the viewer a means to consider not only the geometry of space but the logic of space. This is really quite extraordinary given that Escher failed mathematics in a traditional classroom, and that he did not pursue formal mathematics training after that. We are finding parallel breakthroughs in LTTA classrooms around the world."²² EWM's programs support this claim and confirm that visual learning of mathematics, especially learning mathematics through the arts can offer several benefits for every actors of the education process, including students, teachers and parents.

As successful international examples have shown, LTTA programs can "facilitate the development of analytical and problem-solving skills; stimulate natural curiosity; cultivate a broad range of thinking skills; make learning relevant for students of the many diverse cultural backgrounds that exist in today's schools; enhance teamwork; strengthen the ability to use and acquire information and to master different types of symbol systems; develop creative thinking skills and thereby access to higher order thinking skills; serve as a vehicle to help students make meaning of what they are learning"²³ and can increase parental engagement.²⁴

The creative, artistic, and playful approaches enable students to familiarize and better understand the abstractions and algebraically formulated regularities of mathematical thinking while also contributing to their skills in working with abstract notions and applying systems thinking in problem-solving and decision making. The approaches discussed here extend the regular classroom instruction in — at least — two essential ways: in their

²¹ Marc Ten Bosch, "What is that shape at the end of the trailer?", Marc Ten Bosch Blog, 2014, <http://marctenbosch.com/news/2014/04/what-is-that-shape-at-the-end-of-the-trailer-hd-screenshot>, last accessed 02.12.2014.

²² Angela Elster and Peggy Ward, "Learning Math Through the Arts", in Michele Emmer, ed., *Mathematics and Culture V*, Berlin – Heidelberg – New York: Springer, 2007, p. 173.

²³ Angela Elster and Peggy Ward, "Learning Math Through the Arts", in Michele Emmer, ed., *Mathematics and Culture V*, Berlin – Heidelberg – New York: Springer, 2007, p. 169.

²⁴ Angela Elster and Peggy Ward, "Learning Math Through the Arts", in Michele Emmer, ed., *Mathematics and Culture V*, Berlin – Heidelberg – New York: Springer, 2007, p. 171.

methods and in their thematics. By providing opportunities for the teacher to experiment with the role of a facilitator, EWM's workshops also let the students solve mathematical problems through playful participation and hands-on activities. Students and teachers, while testing their own creativity, perform such skills and abilities, which have remained latent in traditional classroom processes.

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