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Contents

How AI Can Be Applied in Creative Fields

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Abstract. Defining creativity has been a question for centuries. Artificial Intelligence methods are mainly applied in well specified fields of studies, which can be evaluated in an objective way. This paper focuses on research in creative fields, such as visual, linguistic, and musical creativity. The connection to general AI is also described. Finally, we also question if these methods can be considered as creative.

Keywords: Machine creativity, Artificial intelligence, Neural Network.

1. Introduction

Machine creativity is one of the few topics where humanities and computer science meet. It serves several purposes. Experimentation in this field can be used both for creating something new, and for finding out more about human creativity. This paper describes some areas where current research is happening, but first it is important to define machine creativity and to talk about the history of it.

According to the Association of Computational Creativity, machine creativity is defined as the following [3]: *"Computational creativity is a multidisciplinary endeavour that is located at the intersection of the fields of artificial intelligence, cognitive psychology, philosophy, and the arts. The goal of computational creativity is to model, simulate or replicate creativity using a computer, to achieve one of several ends:*

- *to construct a program or computer capable of human-level creativity*
- *to better understand human creativity and to formulate an algorithmic perspective on creative behavior in humans*
- *to design programs that can enhance human creativity without necessarily being creative themselves*

The field of computational creativity concerns itself with theoretical and practical issues in the study of creativity. Theoretical work on the nature and proper definition of creativity is performed in parallel with practical work on the implementation of systems that exhibit creativity, with one strand of work informing the other."

This is the most precise definition that can be found but it still leaves plenty of questions. What is human-level creativity? How can creativity be measured? If a machine only does actions that were told by a human, is it even doing anything creative [2]? In the following sections this paper will try to find answers to these questions, but before that it is important to talk about when research started in the area.

The science of creativity as we know it today first appeared in 1950 when a paper by JP Guilford was published [10]. Guilford was an expert in psychometrics who separated the term creativity from intelligence, and he defined it as a measurable psychological power or propensity. As the Turing test appeared in the 50s, we can say that testing creative aspects of machines has been common for a long time. Research professor Margeret Boden published two relevant books about AI: Artificial Intelligence and Natural Man. What made these books interesting was the reactions it received - some users found the topic of creativity to be out of place [9]. As Artificial Neural Networks gained popularity in the 1980s the innovation aspect of computers got more relevant. The first time someone used Neural Nets for this purpose was in 1989 by Peter Todd [33]. The network generated music in an uncontrolled manner. In 1992 this was extended using a so-called distal teacher approach, which is based on using 2 neural networks. These 2 steps were highly important, as multiple neural network architectures (like Generative Adversarial Networks [14]) continue to be the most commonly used methods in research. In the following section some of these papers will be discussed in more detail, while also touching up on related questions.

2. Relevant Works

Types of artistic creative products can be distributed in groups; the paper does this for convenience.

2.1. Visual and artistic creativity

Visual and artistic creativity is mainly related to abstract and representational art. Mathematic formulation of visuals, already appeared in the 17th century – René Descartes and Pierre Fermat created what we today know as Cartesian geometry [29]. Harold Cohen is considered as one of the pioneers of generative art. He was British artist, who created AARON, a computer program which creates artistic images [16]. He began the development in 1968 at the University of California, San Diego, but he continuously worked on it throughout his life. Cohen does not consider the art it generates creative, as it just follows the style that he had previously hand-coded, but it influenced research for the next decades.

Art, Creativity, and the Potential of Artificial Intelligence by Marian Mazzone and Ahmed Elgammal [24] tries to find the answer to both machine creativity on its own and related to human creativity. As stated in section 1, GANs are a very commonly used methodology for generating something new. In this paper a similar idea was introduced: CANs (Creative Adversarial Networks). The main difference is that there is no curation on the dataset to enforce creativity. The author's goal was not to create something similar to human art, but to create something completely new. The network chose everything for generation, including style, texture, colours, and subject. Reactions to the generated images were rather positive, most people couldn't tell that the paintings weren't human made and were interested who the artist was. The latest image collection can be seen at figure 1.

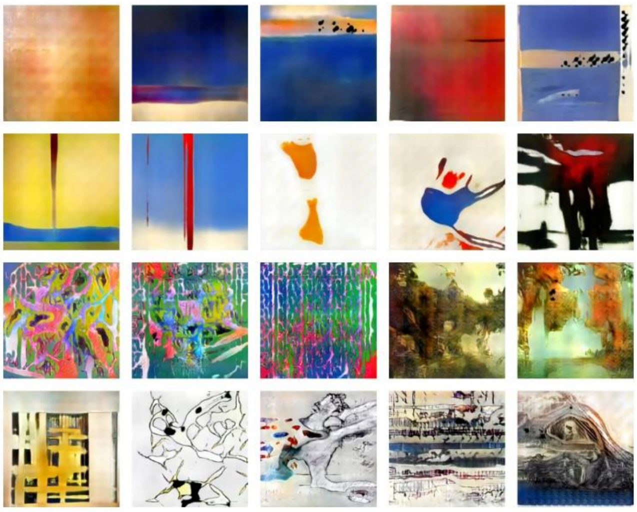

Figure 1: Examples of generated images [24]

In Sketch-to-Art: Synthesizing Stylized Art Images from Sketches, the authors decided to combine two tasks into one: Sketch-to-image synthesis and Style transfer [5]. They suggest that the method can reduce repetitive work and could speed up artist's work. As these are generative tasks, a GAN was used here as well. In the model they implemented three novel components: Dual Mask Injection (a trainable layer that increases content faithfulness), Feature Map Transfer (an adaptive layer that extracts only the style information of an input image) and Instance De-Normalization (to effectively disentangle the style and content information). The model was trained on Wikiart images of different artistic styles. Using human evaluation, they concluded that their architecture yields consistent performance.

Creative Machine Performance: Computational Creativity and Robotic Art by Petra Gemeinboeck and Rob Saunders [13] focuses on an even more physical approach, where robots create actual material art. It takes place in an installation called Zwischenraume, where autonomous robots are placed, and try to create something artistic from a room that looks quite common. The robots rely on colour histograms, blob detection and frame differencing. The method is not as common - it uses a neural network for reinforcement learning, to be more exact - implementing Q learning. The machines are equipped with a motorised hammer, chisel or punch, and a camera to interact with the other machines. The robots try to sculpt something from the walls and get reward from the network by creating something new. It is important to note that this is a more human oriented approach, as the response of the audience is also taken into aspect by the neural net, it's evaluated in the so-called state. The research was successful, it received several awards. In figure 2 a creation of the robots, and its vision is shown.

Figure 2: Zwischenraume [13]

2.2. Musical creativity

As music can be easily mathematically formalized, it is no surprise, that algorithmic composition has a long history. Mozart's Musikalisches Würfelspiel (German for "musical dice game") is a more than 3 century old example [28]. In this piece, precomposed sections are placed after each other, and randomness is introduced – through dice throws. The pioneer of ambient music – Brian Eno – created the album "Ambient 1: Music for Airports", which can also be considered as generative art. It used a series of semi-unpredictable processes, which caused it to play differently every time someone listened to it. Another critically acclaimed musician, Icelandic singer and songwriter - Björk, teamed up with Microsoft, and used an AI, which collected data about the weather using a visual input, to use the results as parameters to determine the choral arrangements in a piece of music [8]. People coming from scientific background are also still active in the field, in the following the improvements, and new approaches from recent years will be discussed.

Flow Machine technologies, created by the company Sony, aided the first AI-human collaborated album – *Hello world* [25]. These algorithms can be used for multiple purposes, such as generation of melodies chords and music bases. The creators of Flow Machine emphasize that their product was not created to generate music but is a tool for creators to get inspiration. They mainly rely on statistics for the algorithms (such as Markov models), which could imply that they cannot be creative on their own but aim to help humans doing creative work. SKYGGE, a French pop artist used these methods to create an entire album, with the help of other musicians coming from various backgrounds and genres, with one goal – to prove that AI can be used to create music that is enjoyable for humans. The author of the paper *Artificial Intelligence & Popular Music: SKYGGE, Flow Machines, and the Audio Uncanny Valley* believes that using artificial intelligence in the field will get more and more common and draws an interesting comparison – not such a long time ago Auto-Tune was considered as cheating, but in today's music it is completely legitimized and used in obvious ways.

Audio mastering is the process of enhancing a piece of music in post-production with things such as increasing loudness, making it clearer, and augmenting it in such a way that it sounds similar on different sound systems. This task is on the verge of a creative task, as it heavily relies on a branch of physics – acoustics, but in a lot of cases the songs can be improved with clever ideas, and there are famous mastering engineers with a well distinguishable style. AI is starting to get more relevant in this field as well, with companies such as LANDR and Cloud-Bounce proposing to master songs without the help of humans and relying purely on algorithms [32]. Currently these methods cannot compete with human engineers, but it is a much cheaper and more accessible way for artists to meg their music mastered. As they allow users to finetune the masters using a few knobs, they can also be used by musicians to create an initial master so that they can later show an engineer what sound they are going for. Using AI in this field is a fresh concept, so it is possible that in the future algorithms will be on par with engineers.

Granular Sound Synthesis is an audio generation technique that makes use of previously existing audio by slicing it into so-called grains and rearranging them to create something new. Adrien Bitton, Philippe Esling and Tatsuya Harada created a Neural Network for this [7]. They used 3 datasets:

- Individual note recordings of instruments (Oboe, Flute etc.)
- Drum and percussion recordings
- Recordings of animal sounds

This was research of a smaller scale but it is interesting to see raw audio being generated with controls for composition purposes, by using a generative model. The aim of it was to enrich the creative use of neural nets in musical sound synthesis.

Ants Can Play Music by Christelle Guéret, Nicolas Monmarché and Mohamed Slimane [15] is a music generation tool focusing more on the melody element, which is influenced by how ant colonies work. The method (in most cases) is guiding the search agents (-the ants) towards promising solutions using a global memory. The idea is to create a graph of which the ants must choose an edge, which corresponds to a certain musical note. This is shown in figure 3.

As in other artforms – evaluating generated music is not a trivial question. Relying on human evaluation is a common choice, in *Are you ready for artificial Mozart and Skrillex? An experiment testing expectancy violation theory and AI* music [21] they decided to do this. They recruited participants from age 19 to 73 to give their opinions on generated pieces from two genres: classical and EDM. They separated these two cases because of multiple differences between them, such as harmony, tempo, style and structure, but also because usually people

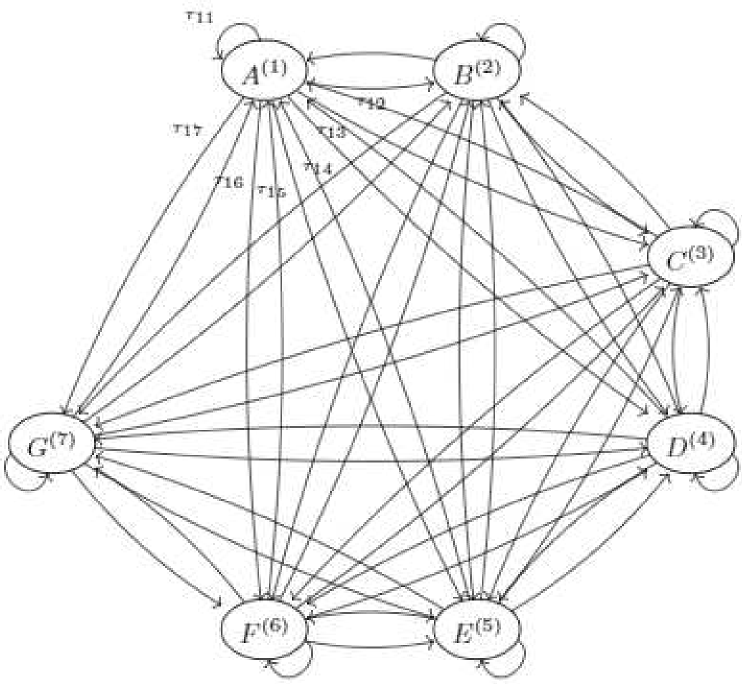

Figure 3: Chosen notes by the ants in the graph representation [15]

consider classical music as less digestible to the general public, opposed to EDM. They decided to use three measures:

- Expectancy violation scale: how much the quality deviates from what the participant expected
- Evaluation of music: assess the musical quality
- Attitudes toward creative AI: assess how much the participant believes in existence of machine creativity

The study showed that people who correctly expected not to enjoy the music hated it less than the people who expected to like it, but did not – the opposite was also true. It also became clear that the genre heavily influenced the results, as the partipicants had formed preconceptions in their minds beforehand. In conclusion the authors say that appreciating new things comes from an open-minded attitude.

Music is a creative field where collaborations are quite common, in these cases all artists have legal authorship over a piece of music, but how does this change if one of artists is an algorithm [20]? This debate dates back to at least 50 years, and legal scholars still did not find an answer they agreed on. An authorship is considered to be original if it owes its origin to the author; and possesses some creative spark. Is this the case if a musician relies on an algorithm? On the other hand – can a machine's work possess a creative spark if it is restricted to create art between the boundaries of what it thinks could be a part of the database? The paper draws an interesting comparison that human musicians also limit themselves by their experiences, for example western artists rely on using 12 musical notes, eventhough using more would be physically possible, and has been done in other regions. The author of *O.K. Computer: The Devolution of Human Creativity and Granting Musical Copyrights to Artificially Intelligent Joint Authors* says that making AI joint authors would be the best choice. This implies that AI needs to be given rights and needs to be regulated. This however raises the question: what would a robot do with its payment? An AI marketplace could require financial support, but it still is not trivial how an entity could administer transaction costs. A solution, the

Collective AI Rights Organization is functioning in the same way that Performing Rights organizations do and is comparable to a relationship that human authors have with their publishers. In conclusion the author says that the law should remove barriers to authorial equity and make collaborations with AI as easy as possible.

2.3. Linguistic creativity

Usually for people not in the field, a machine is considered intelligent when it can explicitly communicate with a human. Natural Language Processing is the segment of AI that is solving problems connected to this. The Turing test (originally "imitation game") was created by English mathematician, Alan Turing, to test a machine if it is capable of exhibiting intelligence that is indistinguishable from human intelligence [34]. ELIZA is a famous NLP program, created in 1966 that Turing's test was done on [36]. It could communicate with humans, using a simple hard-coded structure. This program cannot be considered creative, but perhaps it influenced more research in the field. In the following I will give current examples.

Hierarchical Neural Story Generation by Angela Fan, Mike Lewis, and Yann Dauphin [12] was not the first research group trying to write stories. They saw the errors in previous methods, namely that a lot of stories didn't follow a narrative or weren't consistent at all. They decided to fuse two methods that have been used before by other researchers:

- Convolutional Network
- Sequence two sequence model

They gave the model a big database of texts to learn how to write. After teaching they were hoping to have a model that worked as the following: they gave the model a prompt that they got from reddit's writingprompts forum, and the computer continued the story, that was consecutive and followed the given idea. The network could produce fine results, but it had a few errors, mainly: grammar errors, and producing generic results compared to human prompts. The latter came from the model relying on probabilities of the chosen word, and this caused rare words to be an unpopular choice, for example many stories start with *"the man"*. However, the research team concluded that their model was an improvement overall.

Story generation tasks are usually inconveniently evaluated by humans. The authors of *Evaluating Story Generation Systems Using Automated Linguistic Analyses* [26] proposed a method to make this easier. The following metrics are calculated on the outputs of the story generation algorithms:

- Story-Independent Metrics
  - Sentence Length: number of words in a sentence
  - Grammaticality: calculated using a rule-based system
  - Lexical Diversity: unique words divided by all words
  - Lexical Frequency: measure of uncommon words
  - Syntactic Complexity: number and length of syntactic phrases in a sentence
- Story-Dependent Metrics
  - Lexical Cohesion: Jaccard similarity and embedding similarity of the sentences occurring in a given story
  - Style Matching: comparing sentences by counting how many times a given word category appears, using part-of-speech (POS) tagging
  - Entity Coreference: proportion of noun phrases in the sentence that co-referred to an entity in the corresponding story

They evaluated different story generation methods using these values and showed that there is a statistic difference between them, which implies that these metrics could be used to highlight differences between algorithms.

PoeTryMe is a modular Portugese poetry generation architecture, that was created in 2012. In 2014 a Spanish version was created, which Multilingual extension and evaluation of a poetry generator [19] extended to the English language. The architecture is shown in figure 6. A lot of parts of the original architecture could be kept, but the resources surrounded in dashed lines were updated:

- Lines Grammar: either handcrafter or discovered from human-created text using a semantic network
- Semantic Network: where words are connected according to labelled relations (e.g., synonymy)
- Polarity Lexicon: where words are associated with their typical polarity
- Morphology Lexicon: properties such as POS and lemma
- A tool for syllable division and rhyme identification

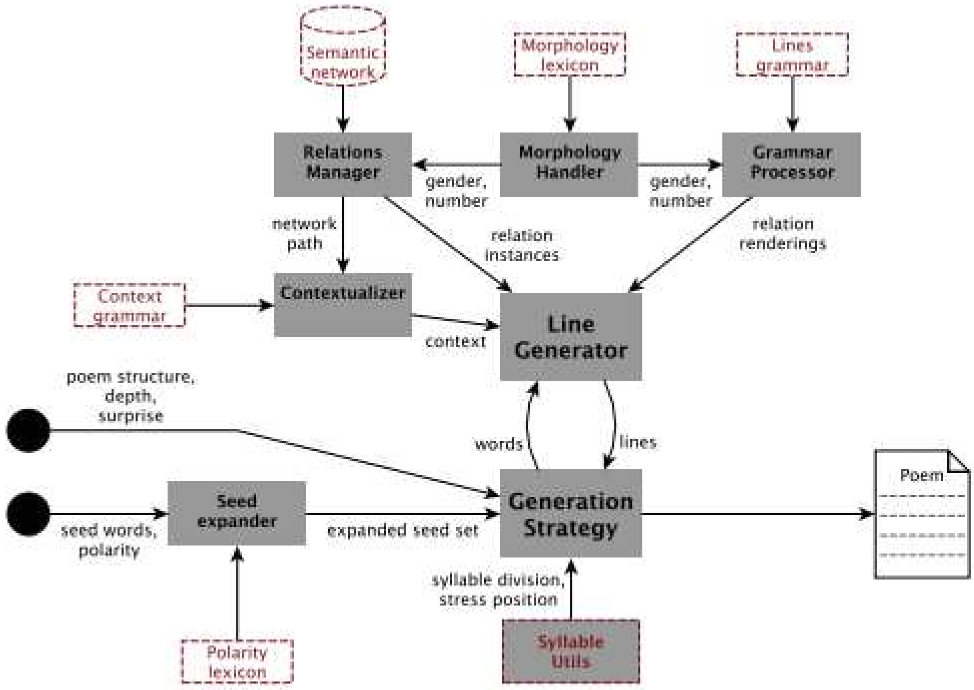

Figure 6: PoeTryMe architecture [19]

When evaluating a poem, it is an important aspect that a poem must fulfil certain structural conditions. The authors aimed at assessing three aspects:

- Poetic Features: the conformance with the metre or the rhymes
- Structure variation: to assess that the system can generate different results
- Topicality: the topic of the poem should have a semantic connection to the words provided in the poem

Children's Evaluation of Computer--Generated Punning Riddles by Kim Binsted, Helen Pain and Graeme Ritchie [6] tried to find out if a computer can generate puns. They developed a generator called

JAPE which created puns based on a database of joke collection books. It mainly relied on ambiguity in the English language:

- Juxtaposition: placing confusable segments near each other
- Substitution: substituting a confusable segment for another
- Comparison: explicit comparison of two confusable texts

In the first tries the puns were evaluated by adults. Interestingly they found quite controversial jokes, in the aspect that some of them found the puns hilarious while others didn't find them funny at all. In the final test 122 primary school aged children evaluated the puns by 3 aspects: *"jokiness"*, *"funniness"* and *"heard before"*. They were given generated puns, puns written by humans, and non-jokes. The response on the generated puns looked like the following:

- Jokiness: They found the puns to be less *"jokey"* than the ones written by humans, but more *"jokey"* than the non-joke ones. The latter was expected.
- Funniness: Similarly, to *"jokiness"* the children found puns by humans funnier and non-jokes less funny than the generated ones.
- Heard before: Interestingly some children said that the generated puns seemed familiar. This could mean that already existing puns were regenerated (or at least the concept of it was similar to an already existing one).

Although the research wasn't successful, it is still interesting to see that young children seem to agree much more on what they find funny, than adults.

As riddles are believed to be one of the earliest forms of oral literature, *RiddleSense: Reasoning about Riddle Questions Featuring Linguistic Creativity and Commonsense Knowledge* [4] is also a paper that deals with AI and literature. Answering riddles is a challenging cognitive process. The authors present a multiple-choice question answering task, which comes with a large dataset. They also evaluated commonly used language processing models. There was a large gap between computized and human performance, which suggests an intriguing future in the field.

Research by Florian Pinel and Lav R. Varshney [30] doesn't fully fall into the category of linguistic creativity, as they tried to make use of computational creativity to create culinary recipes. It made use of analytic algorithms and disparate data sources from culinary science, chemistry and hedonic psychophysics to create recipes that are flavourful, novel, and perhaps healthy. It operates with a human-computer interaction approach. The results it produces is an ingredient list and proportions, and a directed acyclic graph to represent partial ordering of the recipe steps.

5. General Artificial Intelligence

General Artificial Intelligence exists only hypothetically, it is the idea that a machine could learn any intellectual task that a human can [18]. The concept is quite common in science fiction, but it is also heavily connected to creativity. *Theory Blending as a Framework for Creativity in Systems for General Intelligence* [23] says that human mechanisms like analogy-making, concept blending, and computing generalizations rely heavily on creativity. Visions about AI in the past were more optimistic, the General Problem Solver [17] was created in 1959, hoping that research in the area will evolve in the near future. However, AI today is oriented towards completing specific tasks, research with creativity gives hope that general AI will exist sometime.

6. Abstraction and Reasoning

The measurement of artificial intelligence is a complex task, as solely measuring the skill of a machine at a certain task is heavily modulated by prior knowledge and experience [9]. The Abstraction and Reasoning Corpus dataset (abbreviated as ARC) was created to innate human priors and is a better choice to measure human-like intelligence. The goals of ARC are the following:

- Be approachable by humans and machines - should be solvable by a human without any prior knowledge
- Measure generalization, not task-specific skill
- Feature highly abstract tasks that need to be understood using only a few examples
- Provide a fixed amount of data from which new data is not easily generated
- Describe a complete set of priors it assumes

The dataset consists of images in which patterns need to be found. See figure 4. The tasks were tested by higher IQ humans who seemed to solve the tasks successfully. Although this measure still has shortcomings, and still does not fulfil every goal, arguably it is currently the best choice to compare machine and human intelligence.

Figure 4: ARC [9]

6. Discussion and Conclusions

Not everyone agrees upon that a computer can be creative [31]. Harold Cohen rejects the claim of machine creativity even though his program has been hailed to be one of the most creative AI programs. The following quote describes his opinion well: *"It is easy, in short, to assert that machines think, and equally easy to assert that they do not. If you do not know exactly what the machine did, both are equally fruitless in carrying our knowledge, including our self-knowledge, forward."* Other researchers in the topic try to separate types of creativity, like Margaret Boden. She says that creativity can be distinguished into:

- Interactive art: some or all of the creativity is attributed to the programmer or the human participants.
- Standing alone art:
    - Generative art: *"the programmer tweaks no knobs while it is running"*
    - Evolutionary art: the computer produces results by capitalizing on the evolutionary principle of random variation and selective retention

Cohen's method does not fully fit into any of these. Boden makes another distinction: machines that model creativity and machines that do not. The latter type includes machines are not creative, they are just programmes that imitate creativity. She puts AARON into the former category - disagreeing with Cohen. He said the following: *"Creativity...lay in neither the programer alone nor in the program alone, but in the dialog between program and programer; a dialog resting upon the special and peculiarly intimate relationship that had grown up between us over the years."* It can be seen that this is a quite controversial question amongst people in the field. Amongst people not in the field it is a common misconception that the computer can only perform tasks that the programmer also knows how to perform [27]. From this some people draw the conclusion that a machine cannot be creative. A survey has been done about opinions on machine creativity, results of this can be seen in figure 5.

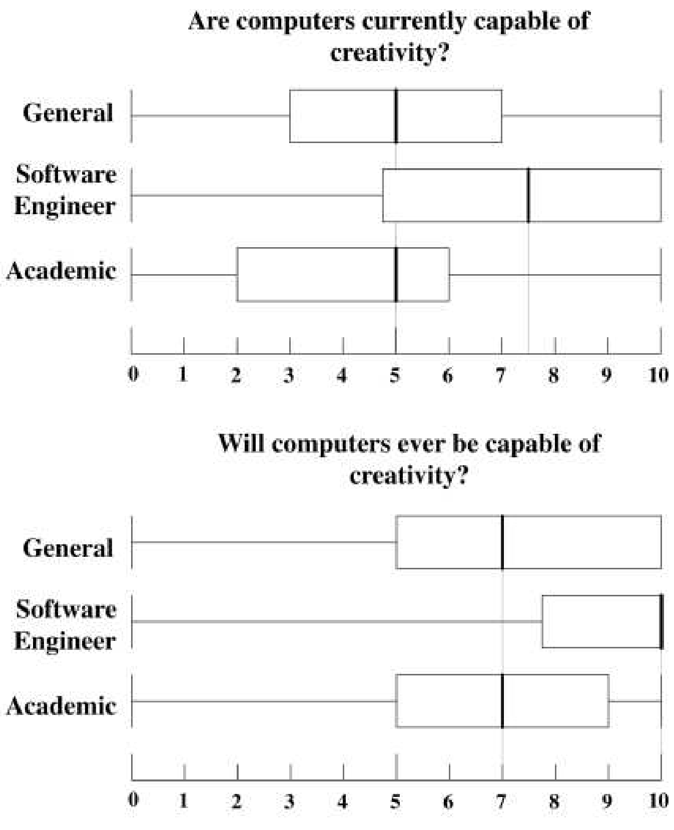

Figure 5: Survey results [27]

A quite interesting result was that in most cases people tend to consider machines that take time to "think" to be more creative. This became clear when putting a loading screen in an analogy generator program, it made people think that something is happening *'behind the curtain'*.

Another point is made by Lev Manovics in *AI Aesthetics* [2]. He says that we as humans consider creative work innovative when it is distinguishable and contains something that is distinct from other works. The problem with artificial intelligence methods (more precisely machine learning methods) is that they try to find ground truths in the database that they were given. Can these algorithms innovate the field by relying only on randomness? If a human wants to collaborate (– needs help) from a machine, will it help the human to be creative, or will it restrict the boundaries of the creative process? Maybe algorithms could make it easier for humans to start working in a new creative field, or to inspire when they are out of ideas, but it is also possible that in the long run it will just make all art less salient.

Perhaps one of the most commonly asked question - not only in machine creativity, but AI generally - is the responsibility aspect. Can the programmer who did some research in the area be held responsible if the creation starts being offensive, or even dangerous? There is no clear answer for this, but it's getting more and more relevant.

7. Future

As seen in the paper, it is very hard to draw the line where creativity starts, but in our opinion, it already exists, although it is still fully in the research phase. Perhaps the most relevant topic for a computer scientist is the question whether computer source code will be generated, and maybe even solved better by machines. We however find the humanitarian aspect more interesting, as we still know very little about the purposes of our need for creativity, and how are brains work differently when doing something creative. In our opinion machine creativity will not replace human creativity, since most people do creative activities for themselves, not just to get a certain result. Perhaps in the future machines will help us understand our creativity a bit more, but in worst case, art will be created that is enjoyable and interesting to humans.

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E-learning in Teaching Basics of Graph Theory

Milan POKORNÝ

Abstract. The pandemic situation, caused by COVID-19, has significantly influenced the way of teaching at Slovak universities. Contact lessons have been completely banned and replaced by distance learning or on-line learning. In the paper, we analyze results of teaching basics of graph theory by a combination of video lessons and an e-learning course. Moreover, we compare the results of internal and external students.

Keywords: e-learning, blended learning, modern technologies in education, teaching mathematics

1. Introduction

In the beginning of 2020, the spread of COVID-19 has changed the way of teaching all over the world. By Reimers et al. [6], *"many governments are implementing measures that limit the number of people congregating in public places. Such measures have disrupted the normal functioning of schools and universities."* Thus, schools and universities have to use alternative methods to continue with lessons when contact teaching in a classroom is not possible. Naturally, the aim is to minimize negative effects of the ban of contact lessons on a level of students' knowledge.

At Slovak universities, face-to-face teaching was banned in both terms of the 2020/2021 academic year. To save the teaching process, online learning increased its use. However, majority of teachers had only limited experience with online learning or e-learning. In a very short time, teachers had to make a change to online teaching. They had to get used to teach from home or from an empty classroom. By Attard and Holmes [1], *"teachers were forced to rely on digital technology as the prime teaching and learning resource regardless of their existing technology-related beliefs and practices."* Fortunately, teachers could utilize experience from countries where online courses are an integral part of learning process at universities. Makamure and Tsakeni [4] conclude that *"the use of online platforms for teaching and learning is possible despite the challenges faced. Moreover, from now on, online classrooms could be part of the new normal in schools where they were not previously used."*

There are several ways how to ensure a high quality educational process. One of them is a proper use of modern technologies. For example, e-learning seems to be one of possible teaching methods. By Ehlers and Hilera [2], *"e-learning refers to a variety of different forms of technology-supported learning, usually characterized as an application of knowledge, information and educational technology to link people to each other and/or with educational resources, for the purpose of education."* The suitability of e-learning in teaching at universities was proved in a lot of studies. As for mathematics teaching, examples of a proper use of e-learning or blended learning can be found for example in [3,5,7].

2. Basics of Graph Theory

Our faculty primarily focuses on preparation of future teachers. The future teachers at primary schools have to master several subjects from mathematics. One of them is Basics of Graph Theory. The students obtain knowledge from the graph theory and its application to solving real life problems. Special stress is put on didactical possibilities of graph theory utilization in different parts of teaching mathematics at primary schools.

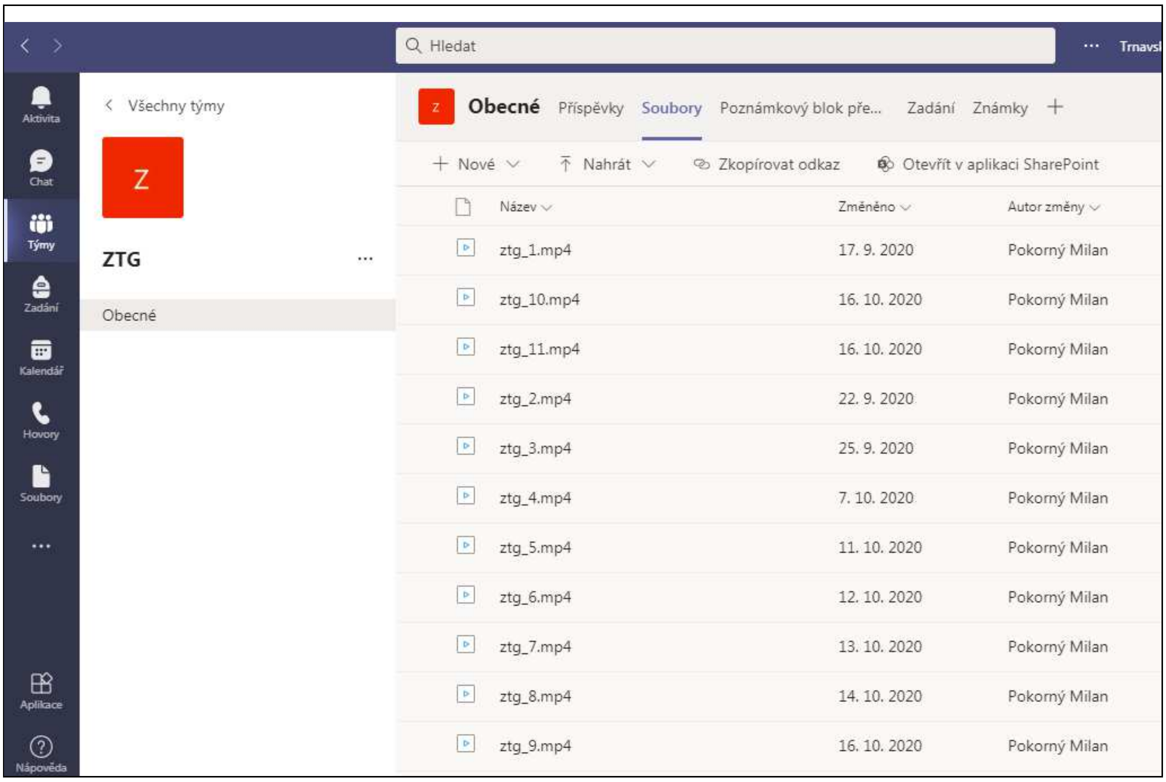

Figure 1: Video lessons in Teams

In the previous academic years, the subject was taught by blended learning, a combination of face-to-face lessons with a teacher in a classroom and an e-learning course. Our experience with this modern method of teaching was positive. We were satisfied with the level of students' knowledge. Moreover, the feedback given by students was really positive. Thus, we did not plan any change of teaching methods. However, the pandemic situation caused the ban of face-to-face lessons. We decided to replace them by video lessons in Teams (see Figure 1).

It is generally known that mathematics should be learned by an active approach of the learners, not by a passive transmission of information from a teacher to students. It means that the students cannot watch the video lessons like a movie. Thus, we gave instructions to our students how to work with the video lessons to strengthen the active way of learning. For example, the students were encouraged to stop videos, make notes, and solve problems by their own way.

3. Analysis of Results

At the end of the term, our students had to pass the final test, which we consider as a measure of the level of students' knowledge. The test consisted of ten problems, ten points each. To pass the test, the students had to obtain at least fifty points. The average score of 64 students was 77.13, median 80, and the standard deviation 14.36. All 64 students managed to pass the test. Thus, we can conclude that the level of students' knowledge is sufficient.

In our country, it is often stated than there is a gap in the level of knowledge of internal and external students. Thus, we compare the results of these two groups of students in our subject. From 64 students, 41 students were internal and 23 students were external. The average score of 41 internal students was 78.34, median 80, and the standard deviation 13.77. The average score of 23 external students was 74.96, median 80, and the standard deviation 15.41. The results of the students can be seen in Figure 2.

As we can see, the average score of the group of internal students is slightly greater. To test the significance of the difference, we use the methods of statistics. Firstly, we test the normality of the results of both groups. We use the Shapiro-Wilk normality test. For internal students, the value of the test statistics W is 0.912, and the critical value for 10 per cent probability of type I error is 0.954. Thus, we reject the null hypothesis about normality of the results of the internal students. Similarly, for external students, the value of the test statistics W is 0.908, and the critical value for 10 per cent probability of type I error is 0.928. Thus, we reject the null hypothesis about normality of the results of the external students, too. Reasons for rejection is visible in Figure 2. We can see that there are two types of students. The majority of students try to learn as much as possible. However, there are also students who learn only sufficient amount of knowledge to pass the final test. That is why there is quite a lot of students with the score of the final test in the interval [50-59].

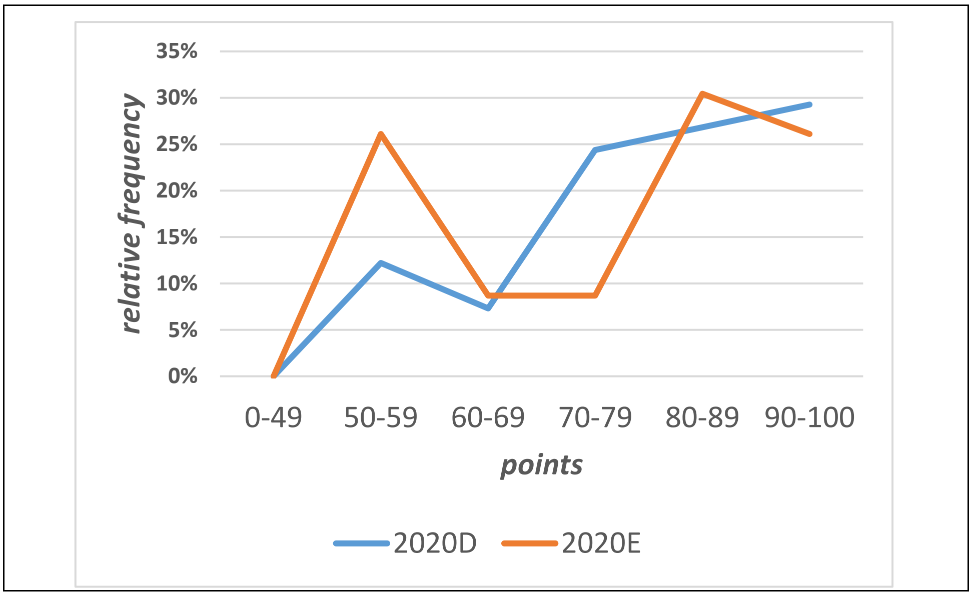

Figure 2: Results of the final test (2020D means internal students, 2020E external students)

Since we reject the normality of the results of the final test in both groups, we use a non-parametric Mann-Whitney U test to compare the significance of the difference between internal and external students. The value of the test statistics Z is 0.70 and the 95% critical value accepted range is [-1.96:1.96]. Thus, we accept the null hypothesis 'There is no significant difference between the results of the internal and external group in the final test'. To conclude, the score of the internal students in the final test is not significantly better than the score of the external students.

4. Conclusion

From the results of the students in a final test it follows that a combination of video lessons and an e-learning course is a suitable method of teaching Basics of Graph Theory, which can eliminate the negative impact of the ban of face-to-face lessons caused by a COVID-19 pandemic. However, if we compare the results of students in the 2020/2021 academic year with the results of the students in the previous academic year, we can observe a slight decrease of the results (97 students, average score 82.19, median 85, standard deviation 13.37). Thus, if it is possible, in the following academic year we plan to return to blended learning again. However, the video lessons would be used as an additional study material.

We can also observe additional benefits of integration of modern technologies in teaching mathematics at our faculty. One of them is that a combination of video lessons and an e-learning course can remove the gap between the level of knowledge of internal and external students. The second benefit is connected with the use of blended learning also when a face-to-face lessons are allowed. Our experience shows that the students taught by blended learning are better prepared to a sudden change of face-to-face teaching to on-line learning. That is why we recommend to increase the utilization of modern technologies in teaching.

4. Acknowledgement

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Barriers, Role Models, and Diversity – Women in IT

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Abstract. Despite the growing need for IT professionals all around Europe, women are still severely underrepresented in IT-related fields. According to Eurostat, female IT specialists constitute only 16.5% of the workforce in the EU28 countries. Gender imbalance, however, is conspicuous already in higher education: only 23% of students majoring in IT are women. The reasons why girls are reluctant to consider a career in IT are complex. Based on the analysis of recent literature review papers about young women's barriers, we can differentiate four basic obstacles that keep girls from IT: social, educational, self-efficacy, and labour market factors. In order to overcome these obstacles, the necessary tools are the presence of role models, the promotion of diverse IT paths, and inclusive teaching environments. The present paper aims to introduce a study conducted within the settings of a non-degree, tertiary Computer Science program, with the usual scarcity of female students and a high dropout rate. As part of their program, students also need to attend an interdisciplinary course, in which they are exposed to an inclusive teaching environment, the presentations of role models, and diverse career paths. Before, during, and after the course, students were asked to reflect on the issues of barriers, diversity, and role models, which were analysed in a quantitative and qualitative manner. As a follow up, female graduates of the program, already working as software developers, were surveyed about the same questions, in order to explore what women who do end up in IT careers share.

Keywords: gender, women, barriers, IT, IT education, role models

1. Introduction

One of the biggest winners of the COVID pandemic was the IT sector, as tech companies such as Zoom, Google, and Amazon have gained unprecedented profits over 2020. [1,2] The continuous and rapid growth of the IT industry was obvious even before the pandemic: the IT sector had already been struggling with a significant shortage of qualified workforce both internationally [3,4] and specifically in Hungary. [5] In the past years, however, the demand for IT specialists has doubled. According to a recent study done by the Association of Hungarian Informatics, Telecommunication, and Electronics Professionals, in the next two years 44,000 IT professionals could be employed in Hungary [6]. The supply, though, is expected to lag behind, at about 18,000 professionals. Currently 9,000 tech jobs remain unfilled, and with the rapidly growing demand, the gap is bound to significantly increase [6]. Changes are necessary so that our global need for IT professionals can be met.

Despite the growing need for IT professionals all around Europe, women are still severely underrepresented in IT-related fields. According to Eurostat, female IT specialists constitute only 16.5% of the workforce in the EU28 countries [7]. Gender imbalance, however, is conspicuous already in higher education: only 23% of students majoring in IT are women [8].

According to the literature, we can differentiate four basic obstacles that keep girls from IT: social, self-efficacy, educational, and labour market factors. In order to overcome obstacles such as gender stereotypes linking IT to masculinity, girls' low self-efficacy due to such stereotypes and consecutive computer anxiety, the necessary tools are the presence of role models, the promotion of diverse IT paths, and inclusive teaching environments.

The present paper aims to introduce a study conducted within the settings of a non-degree, tertiary Computer Science program, with the usual scarcity of female students and a high dropout rate. As part of their program, students also need to attend an interdisciplinary course, in which they are exposed to an inclusive teaching environment, the presentations of role models, and diverse career paths. Before, during, and after the course, students were asked to reflect on the issues of barriers, diversity, and role models, which were analysed in a quantitative and qualitative manner. As a follow up, female graduates of the program, already working as software developers, were surveyed about the same questions, in order to explore what women who do end up in IT careers share.

2. Literature Review

In order to find out what the latest research has revealed about what keeps women from the IT field, a dozen review papers, published in the past two years, were selected. [9,10,11,12,13,14] After examining these recent papers, each dedicated to review the latest literature about young women's barriers, we can differentiate four basic obstacles that account for girls' scarcity in IT: social, self-efficacy, educational, and labour market factors.

The most fundamental obstacle that girls face is gender stereotyping, that is, a binary world view that divides the social world into feminine vs. masculine domains and characteristics [15] connecting IT, and generally, STEM[1] to masculinity. [9,10,11,12,13,14] Gender-based social stereotypes can affect how young women's closest environment relates to their career interests, such as their families. It is especially fathers' and male siblings' attitudes that were shown to influence girls' choices. [11] How the media portray the IT field and the IT professional matters as well: typically, it is still the antisocial, male geek that is normalised in the media [10,12], thus discouraging girls from considering IT.

As a direct consequence of gender stereotyping, girls tend to have low self-efficacy in STEM and specifically IT. [9,10,11,12,13,14] They perceive their analytical skills to be worse than they are and worse than boys'. It is also because of this that computer anxiety can develop in girls. [11] The perceived lack of success, then, deters young women from choosing IT as a study and career path.

Many girls encounter IT in schools for the first time, apart from using tech for personal communicational purposes. Both teachers' attitudes and the learning environments influence what kind of IT-experiences young women gain. [9,10,11,12,13,14] A number of STEM teachers reported to have, and act on, stereotypes connected to gender [16], which discourages girls from STEM fields. Male-dominated classes and male-oriented topics can also lead girls into not seeing the benefits and interests IT can offer, hence making them stay away [10,12].

Finally, another chief factor that poses as an obstacle for a larger involvement of women in IT has to do the labour market. [9,10,11,12,13,14] When in school, young women have scarce knowledge about the diversity and reality of careers in IT. Probably due to lack of resources and the rapid growth of the IT industry, schools often fail to provide adequate information about what it really means to work in the tech sector. [12] Without being clear on what areas and activities IT involves, and what kind of skills they require, young women rely on the deficient info media portrays about IT and the IT professional, which most often does not coincide with how they seem themselves (and what they think society expects of them).

Due to the complex nature of barriers young women face, interventions are needed in order to foster girls' interest in IT. We need to put emphasis on providing them role models, to make them see it is an open field for them. [10,12] Role models can also help in promoting the diversity of IT careers. As for their learning environments, girls need to be exposed to IT in inclusive classes

[1] STEM = Science Technology Engineering Mathematics

employing teaching methods that actively work on overcoming gender stereotypes and promoting diversity.

3. Research

3.1. Background

In order to test the above theories within the Hungarian context, a case study was done over the course of the 2020-2021 academic year. Students, enrolled in a recently launched Computer Science (later on referred to as "CS") program at the Faculty of Informatics, Eötvös Loránd University, were the subjects of the analysis.

On average, 50-70 students get admitted to this program, launched just in 2018, but enrolment numbers have been steadily growing year after year since its start. Despite the growing popularity of the program, a significant gender imbalance and a large dropout rate clearly call for amends: only about 20% of its students are female and only about 10% end up graduating at the end of the second year.

As opposed to the bachelor's level equivalent of this CS program, this one is a non-degree program which is pronouncedly "practice-oriented" (see program site2). Students spend their last term as interns at IT companies, and as opposed to BSc-students, those enrolled to this program also have the chance to attend, free of charge, communication training such as professional English language courses.

This interdisciplinary training, managed by the author, was designed specifically in accordance with the above literature, to reflect on gender-positivity, diversity, and inclusiveness within IT, specifically through the introduction of role models. Both with the teaching methods and the study materials, the course was aimed to improve students' co-operational and social skills, while promoting diversity, in order to make them better language users, and also better programmers.

Regarding the contents of the course, they were put together primarily to demonstrate the human side, the social context, and the diversity of IT to students who are interested but may not yet be deeply experienced in the field. The course was divided into two parts (that is, academic terms) in a way that the materials did not only connect to but also derived from one another. While the first part was supposed to build the foundations of the coursework, the second was meant to elaborate on and deepen the concepts and the skills.

All the communication, skills development, and analytic activities of the course were based on eight, high-quality, English-language TED3-talks covering a specific IT topic [see more in 17]. The speakers were selected with an eye for diversity. First, so they can represent and present different subtopics within IT, such as computer vision, machine learning, face recognition, ethical hacking, and data visualisation, showcasing the wide options within the field. Second, the identity of the speakers was also meant to be a testament of difference and inclusion. Regarding their ethnicity and nationality, the speakers are not at all homogenous; in addition, religion and sexual orientation

[2] https://www.inf.elte.hu/content/programtervezo-informatikus-fejleszto-felsooktatasi-szakkepzes-budapesten-es-szombathelyen.t.1442?m=256

[3] TED = Technology Education Design

appear as a matter of choice as well. Most importantly, as far as gender is concerned, it was a very conscious decision to include a fair number of women among the presenters (see Figure 1).

Figure 1: The TED presenters as IT role models

3.2. Methods

At the beginning, in the middle, and at the very end of the coursework, students were asked to do written self-reflection tasks related to the course material. Both in graded and ungraded frameworks, they were prompted to share their opinions on concepts such as role models, motivation, obstacles, and the IT field itself. Students' replies were collected (in the period between September 2020 and May 2021) and analysed (in the period between May 2021 and August 2021), in search of common narratives.

As a follow-up to the above one-year-long study, female graduates of the program were also asked in a survey (between May 2021 and August 2021) about their experiences with role models, motivation, obstacles, and the IT field. In addition, they were also asked what they think made them successful, given that both as women and as graduates of a CS program they were exceptional.

3.3. Findings

In order to keep track of students' views about role models in IT, they were asked at the very start of their CS studies, during the course (in the middle of term 1, at the end of term 1, and in the middle of term2), and at the very end of the course, that is, at the end of their first year in the program, to reflect on questions related to motivation and inspiring characters.

At the beginning of their CS studies, the large majority of students replied they do not have relatable role models in IT. Most of the students who did report to have a role model mentioned someone who is well known from (not only tech-savvy) news, such as Elon Musk, Bill Gates, or Jeff Bezos. Students, therefore, demonstrated to have superficial exposure to the field, and practically no role models, when they start their studies.

However, when asked, during the different stages of the course, to reflect on the IT professionals they were being exposed to in the TED talks, the majority of students reported to be inspired by them "for figuring out their ways," "working in fields they love" or "helping to make society better". Some students even confessed to wanting to work in similar fields as the speakers, such as animation.

At the end of the course and their first year, students were once again asked the same explicit question regarding whether they have role models in IT as at the very start. The overall response rate was only slightly better than at the beginning: the majority of students still felt they do not have "role models" in IT.

Students were also prompted about what they perceive to be their main barriers on the IT field. The most frequent replies were laziness, a not necessarily discipline-specific obstacle, and that they do not know what they are doing here or in the future. Students felt the IT field was unclear to them, just as their place in it. At the end of the course, there were less replies that questioned how IT was related to the real world but uncertainties about their place remained. Some of the female students underlined gender as an obstacle and at the end of the course several of them brought up the female IT experts from the TED talks, both as reminders of the problem and as counterexamples.

As a follow-up to the study conducted during the course, the alumnae of the class of 2019 and class of 2020 were also interviewed. Each of the five female graduates of the program got hired by the IT company, affiliated with the program, where they did their internships. Both as women in IT and as graduates of the CS program, they were exceptional, so their input promised to shed some light of the narrative of the successful path-takers. When reflecting on motivation for the field and role models, their responses were not too unlike the ones still at the beginning of their IT paths: even these women, already working in IT, reported not to have role models when growing up or attending school. Some of them, though, did mention that having started work, now they could name some people who inspire them. As for barriers, several of them seemed to be more aware of gender as an obstacle, in family circles, among acquaintances, and even in school. Several of them, however, mentioned that at their workplace they do not feel anymore that gender matter; in fact, they have supportive environments and colleagues. When asked what they attribute their success to, they said that they were interested in IT, they disregarded gender stereotypes, and they have a work environment that actively promotes women in IT.

4. Conclusion

The findings of the study reveal that even students who are interested enough to give IT a shot by enrolling to a CS program have superficial knowledge about the field. Only a few of them have immersed themselves enough in the domain to be inspired, or be able to name, specific people in the field who are personally relatable. According to Gibson's career theory, however, the presence of a role model or mentor is essential for success. [18]

Even when students are exposed, for multiple months, to stories and works of people who are more relatable than tech giants such as Elon Musk or Bill Gates, they failed to label them as "role models". Perhaps the exposure was still not deep enough; the IT experts, as TED speakers, were still too unapproachable for students; or the concept of a "role model" in their native language (Hungarian "példakép") is simply too abstract for students to categorize a "mentor figure" into it.

As a consequence, it might be more effective to expose novice students, not just to established IT experts, but also to higher-level fellow students or alumnae who can serve as approachable mentors for them, giving inspiration and guidance. Stout el al.'s Stereotype Inoculation Model, that is, the concept to connect in-group mentors, has proven to enhance women's self-concept in STEM, positive attitudes and motivation to pursue STEM careers. [19]

Having relatable mentors could help women overcome some of the main barriers mentioned in their feedback. On the one hand, it can facilitate a better awareness of the IT field and necessary skills through the experiencing sharing process. On the other hand, the presence of female mentors can contribute to lessen another recurring problem, which was gender imbalance. Focusing on what the surveyed alumnae named to be their keys to success, we can conclude that environments that actively promote gender balance can foster women's better involvement and retention. Next to peer mentoring, it also seems vital to create environments that clearly look out for women, not just in rhetoric but also in practice.

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Student's Locality Impact on ICT and Mobile Technology for Real-Time

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Abstract. To evaluate the demography feature impact on students' minds to-wards the Information and Communication Technology (ICT) and Mobile Technology (MT) is a crucial challenge in the international study environment. The present paper explored the locality (rural and urban) impact on students' outlook regarding the technology parameters (attitude, utilization, development, and benefits). The authors applied a non-parametric test (Mann-Whitney U) on 37 features, and 302 samples were gathered from Hungarian and Indian universities. The results of the paper evidence that the locality of students did not impact the ICT and Mobile technology in Indian and Hungarian universities. The authors found that the Hungarian rural and urban students think differently about "High-speed internet with Wi-fi" ($U=1205$, $p<0.05$) but not in the case of Indian students.

Keywords: Impact, Student, Locality, Technology, University.

1. Introduction and related work

ICT and mobile technology have become an essential element in modern higher education. During the Covid-19 pandemic, the use of ICT and mobile technology has increased a lot. Of course, it supported both educators and students in continuing their teaching and learning processes. An exhaustive study is conducted to explore a digital divide among rural and urban students based on computers and their applications [1]. ICT is regarded as a catalyst for reducing education inequality between rural and urban regions [2]. Several researchers investigated the disparity between opinions of rural and urban students and teachers towards ICT, computational thinking, and other technology parameters. The rural teachers use rare interactive functions in presentations as compared to urban [2]. The students living in the capital have a high performance in problem-solving compared to students living in rural areas or weak areas [3]. Students' locality influenced their opinions towards ICT, and urban students found more positive than rural students [4]. A study explored disparity among students belongs to the mechanical focuses towards ICT attitude in Hungary. This study found only one significant variable out of 24 that focused on the requirement of ICT at faculty while selecting for the study [5]. A considerable disparity among students was also found based on locality towards internet utilization [6].

2. Objective and Hypotheses

The main objective of this paper is to explore the impact of locality on the opinions of students of Indian and Hungarian students towards technology. The below null hypotheses are framed:

H01: Locality has no significant effect on the opinions of Indian students towards technology

H02: Locality has no significant impact on the opinions of Hungarian students towards technology.

2. Dataset Description

This paper used a primary dataset collected from the students of Indian and Hungarian universities to compare the opinion towards technology. The name of the Hungarian university was Eötvös Loránd University, and the name of the Indian university was Chandigarh university. The participants' students were studying in a computer science course. In the dataset, we have 37 variables and 337 instances. After the removal the outlier, we have 302 instances.

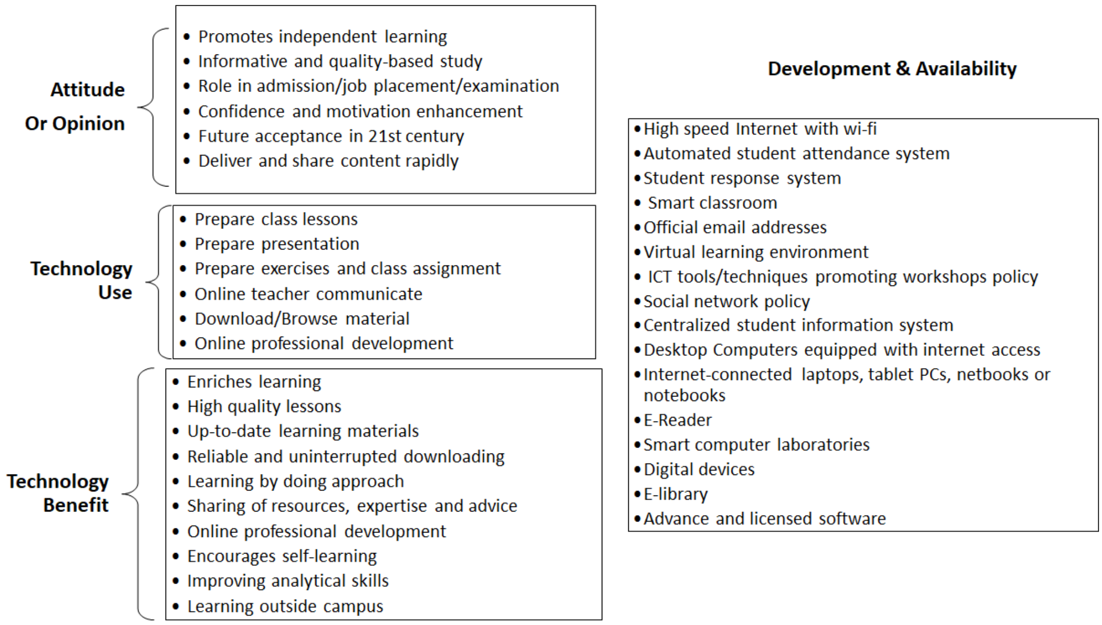

Figure. 1 Variables Under Investigation.

Figure 1 displays the shortened variables used for the analyses. We used 6 variables belong to students' attitude towards ICT, 6 variables related to technology use, 9 variables related to technology use, and 16 denote the development & availability of ICT. The reliability of the samples is 0.841 computed with Cronbach's alpha test. The sample adequacy is 0.89, estimated with the Kaiser-Meyer-Olkin measure, and this adequacy is stamped with Bartlett's test of sphericity ($p<0.05$).

4. Experimental Results

The experiment is conducted in the IBM SPSS tool, and the non-parametric Mann–Whitney U test is used to compare the tech-nology parameters. The group variable is the locality which has two groups rural and urban. Rural students live far from the city in remote areas, and urban students live in developed cities. In Indian samples, the ratio of rural and urban is 50:107, and the Hungarian rural and urban ratio is 24:121. A total of 37 test variables are passed through this Mann–Whitney U test at a 0.05 level of significance. Out of 37 variables, we found only one variable significant. It is applied to the abnormal samples to explore the locality impact on the technology of two countries. This test ignored the required assumptions of normal-ity, unlike the t-test. The below equation is used to examine the effect of locality on the dependant variable.

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - \sum_{i=n_1+1} R_i \qquad (1)$$

Where, U = Mann-Whitney U test criterion, n1 = Indian sample size n2 = Hungarian sample size, Ri = Rank of the variable.

	Indian Student	Mean Rank	*p*-value	Hungarian Student	Mean Rank	*p*-value
High speed Internet with wi-fi	Rural	77.6	0.76	Rural	83.3	0.02
	Urban	79.7		Urban	71.0	

Table1: Locality Impact on Technology.

Table 1 shows the results of the Mann-Whitney U test applied group variable locality. The variable "High-speed Internet with wi-fi" was found significant for Hungarian students, unlike Indian students. Considered this variable for the Indian students, the null hypothesis "H01 : Locality has no significant impact on the opinions of Indian students towards technology" is failed to reject ($p>0.05$). For the Hungarian students, this null hypothesis, "H02 : Locality has no signif-icant impact on the opinions of Hungarian students towards technol-ogy," is failed to accept ($p<0.05$). Therefore, the locality variable has significantly impacted the opinions of Hungarian students. But it did not affect the viewpoints of the Indian students.

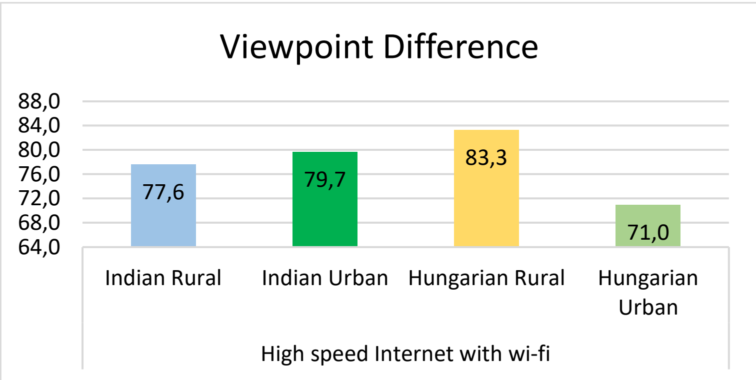

Figure. 2 Mean rank difference between Indian and Hungarian students.

Figure 2 graphs the difference between the opinions of urban and rural students of two countries towards variable "High-speed Internet with wi-fi". The rural students' mean rank is higher than the mean rank of urban students (83.3>71.0). It means that there is a disparity in the thinking of Hungarian urban and rural students. But Indian urban and rural students have no significant difference towards this variable (77.6≈79.7).

4. Conclusion

The present paper compared the opinions of computer science stu-dents of Indian and Hungarian universities. Only one variable, "High-speed Internet with wi-fi," is found significant out of 37 variables. The paper results signify that the Hungarian rural students' opinions are higher than those of urban students (83.3>71.0). This means the rank difference is justified with a significant p-value ($p<0.05$). This outcome is opposite to existing results [4] but supportive of the findings [6]. Based on a substantial p-value, it is proved that the locality has impacted the opinions of Hungarian students. The results of the paper also concluded that there is no disparity in the viewpoints of Indian students ($p>0.05$). The findings of study suggested that the urban students at Hungarian university need to think more positively about the high-speed internet with wi-fi facility. Also, the universitys' administration and technical support can help boost their opinion about it by eliminating obstacles, if any. The Mann-Whitney U test can be used to test the views of university real-time classroom response system "E-lection" [7] in lack of normal samples. Hence, we recommend this approach to assess the opinion of students.

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