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Contents

Educational Issues Raised by the Availability of the Quantum Computer

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Abstract. The development of quantum computers is bringing major changes to the IT sector. These computers, based on completely new principles, can provide effective solutions to previously unsolvable problems. Regulations have already been introduced in the European Union and Hungarian law to confirm that we are getting closer to the era of quantum computers. Therefore, we believe that education and teachers should follow the development of these machines so that future students in the field of information technology, whether they are IT teachers, physicists, or programmers, are not caught unawares. In this article, we present some examples from abroad where quantum computing topics are already included at certain levels of education.

Keywords: quantum computing, quantum physics, primary school, secondary school, higher education, specialization, STEM, education

1. Introduction

News about quantum computing research has become part of our daily lives, with quantum informatics news, speculation, and reports on developments by big companies [11] in the science sections of the online and print press. Legislation and regulations have also been published among countries in the European Union and in Hungary on post-quantum encryption and to support the development of quantum computers [22, 23, 24, 41, 52, 63].

The emergence of these clearly raises interest, speculation along with data security and password protection issues related to quantum computers. There is an increasing need for people to obtain information from credible sources on the operation of quantum computers, their physical basis, their applications, current developments and the expected social and economic impact.

A number of questions have become important: What exactly is a quantum computer? What are the concepts associated with it? What is the basic unit of storage and transmission of quantum data? How is it defined? How is it stored? How do quantum computers work in general? What are the physical principles that underlie the construction of these machines? Are quantum computers likely to replace the computers we have today, and where can we see, try out and buy a machine that works according to this new paradigm?

2. Historical overview

The roots of quantum mechanics in the classical sense can be traced back to empirical physicochemical research in the early 19th century. When investigating the relationship between temperature radiation and spectral analysis, black lines were found in the spectra [7, 8, 54, 55]. This anomaly raised many new questions for researchers, which by the early 1900s were being answered by questions from the field of quantum mechanics, which was becoming a science in its own right.

By the early 1900s, research that correctly described the spectra but used classical theoretical approaches had failed time and again. Planck chose a new way of interpreting the physical properties of atomic oscillators, starting from entropy instead of phenomenological thermodynamics [49, 50]. The relationship between entropy function and thermodynamic probability was already known, as well as the fact that an isolated system takes its maximum value in equilibrium. His assumption was that the number of microstates associated with each thermodynamic probability can be counted, and this is only possible if the energy is divided into parts (finite energy units). In other words, the energy of thermal radiation (mechanical oscillator) is not continuous but quantized.

He reported his quantum hypothesis at a scientific meeting of the Royal Prussian Academy in Berlin on 14 December 1900 in a lecture entitled "Ueber das Gesetz der Energieverteilung im Normalspectrum", which is considered the birthday of quantum physics.

It was a true paradigm shift, which was received with reservations by the leading community of physicists who set the scientific trend and only ratified it years later. However, the initial uncertainty did not prevent the new direction from unfolding, as the first three decades of the 1900s saw a succession of old and new results being overturned year after year. By the end of the first decade, a new discipline had emerged alongside quantum physics: the theory of relativity.

3. The limits of traditional computers

There is a huge demand for quantum computers as a new technology because the Neumann computers currently in use will soon reach - and at some points have already reached - the limits of their technological development, as the trends shown in the following three graphs clearly illustrate.

Moore's Law illustrates the rapid technological development of classical computers. It is not in fact a law, but an empirical observation that the number of transistors in integrated circuits doubles every 1.5 years. The observation is attributed to Gordon E. Moore, one of the founders of Intel, who first wrote about the trend he observed in an article published in Electronics Magazine in 1965 [27]. Although Moore's original formulation was not the same as it was widely reported, it had a major impact on the pace of development by processor manufacturers. According to the original formulation, the complexity of the lowest-cost component is roughly doubling every year, and this rate of development is unlikely to change significantly in the future. For chip designers, this observation became a target to be met and a self-fulfilling prediction for the future, i.e. a complete forecast of the production cycle for many years to come.

So much so that the age of transistors was replaced by the age of integrated circuits, and the classic operating principle was retained, but the desired rate of progress was achieved by means of different technological elements.

The graph below [56] clearly shows the increase in the complexity of integrated circuits, which at first glance appears to be a linear increase, but if we look closely, the vertical axis is logarithmic in scale, so we can see that it is an exponential increase. The horizontal axis shows the year of release of each processor and the vertical axis shows the number of transistors in each chip. This means that smaller and smaller transistors are being built into computer chips, with the most modern processors today fitting a transistor into an area of 20 x 20 silicon atoms. It is clear that this development is unsustainable since sooner or later miniaturisation will reach the atomic scale and then limit the development of the classical type of Neumann computers.

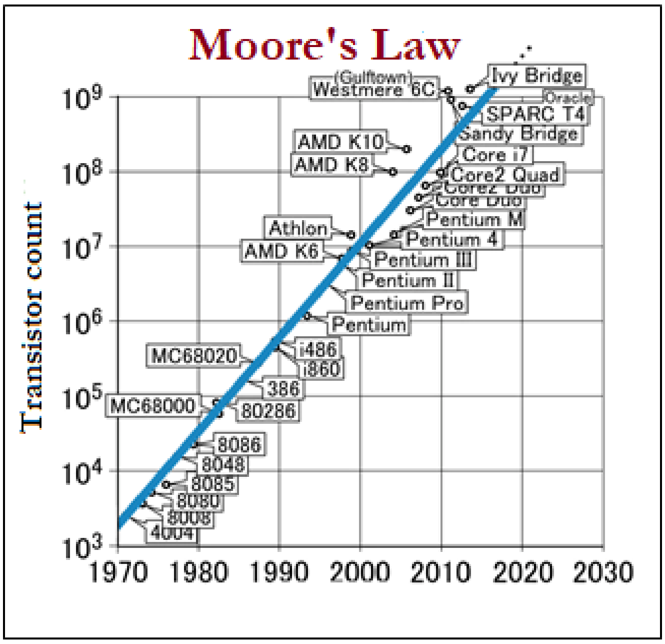

Figure 1: Trend of Moore's law. Edited by Csilla Prantner based on [56].

The extrapolation graph below shows the characteristics of microprocessors as a function of time: number of transistors, single-thread performance, CPU frequency, power consumption, and number of cores [36]. The signal in 2004 indicates the breakdown of the Dennard scaling rule.

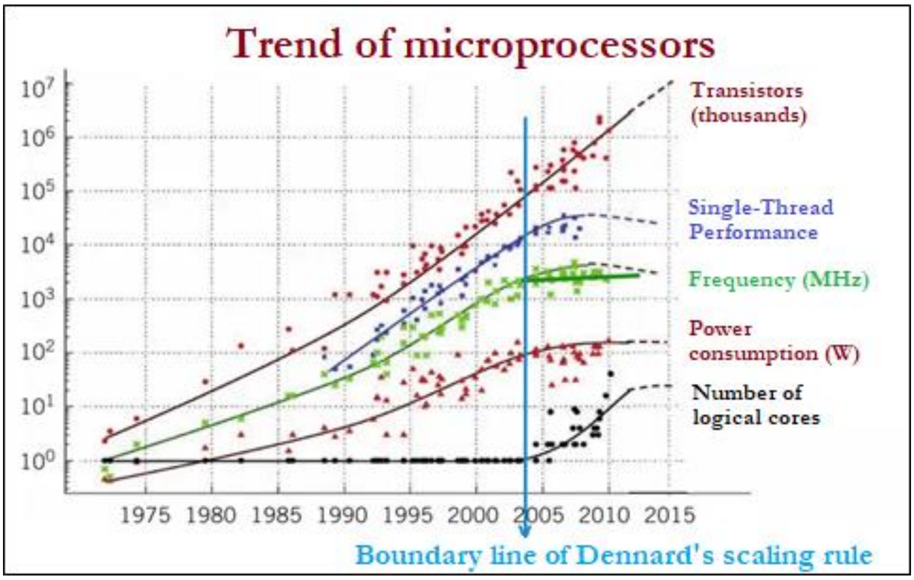

Figure 2: Dennard scaling rule. Edited by Csilla Prantner based on [36].

The rule is also known as Dennard's scaling law, which states that as the size of the transistors is reduced, the power density remains constant, i.e. no matter how small the transistors become, they will still be able to deliver the same power. This discovery foresaw and ensured the development of high-throughput processors for many years to come. The law was originally formulated for MOSFETs based on a 1974 article by Robert H. Dennard. [17].

Looking at the middle of the factors on the right side of the graph, where the rate of change of clock speed is located, since 2004 we see a linear function, i.e. since 2004 processors have been clocked at 3-4 Hz. In the last few years, it has not been possible to increase the clock speed, and since computers perform tasks at the same rate as the clock, the speed at which they are performed cannot be increased. This also shows the limits of the current development of traditional computers.

The third diagram illustrates Amdahl's law, which relates to parallel programming. In principle, parallel programming allows us to speed up the execution of algorithms since several processors can work on the same problem at the same time.

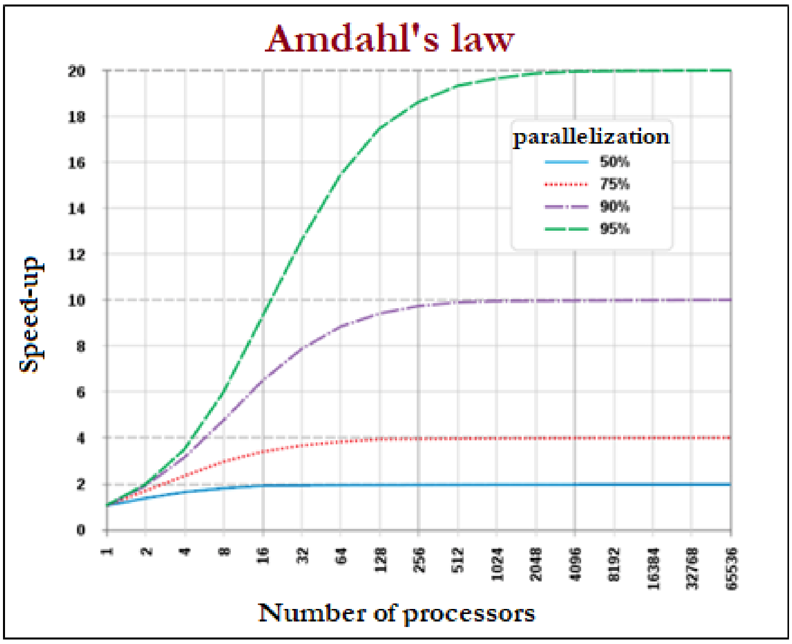

Figure 3: Amdahl's law. Edited by Csilla Prantner based on [66].

Gene Amdahl, who also worked for IBM, spoke at the AFIPS conference in 1967 about how the relatively few instructions to execute in a parallel processing program is a limiting factor on the speed of the program, so adding more processors does not necessarily make the program run much faster. A precise formula for this observation has been formulated by the expert [1]. The basic problem is that there are few tasks that are truly able to be parallelized, i.e., that the individual program threads are so separable that they do not rely on each other's computations or partial results, i.e., the execution of one part of the program does not depend on or influence another. A good example of a problem which can be parallelized is map analysis, where, for example, a large area is divided into smaller areas of the same size and these are analysed in parallel, e.g. which parts contain water or forested areas, etc. In this case, too, the results from each analysed area must be combined to produce a summary. So the point is that there are a few problems that can be well parallelized. Figure 3 illustrates the impact of increasing the number of processor cores on program execution speed for algorithms that can be parallelized in a certain percentage [66].

If we assume that we are solving a problem that is 95% able to be parallelized (green dashed line, only in very special cases), even a number of processors higher than 2048 does not bring any improvement. If we can parallelize 50% of the problems (blue solid line, which is rare), then even more than 16 cores will not bring faster performance. So above this, increasing the number of processor cores is more of a publicity stunt than a real opportunity to be exploited, since the fundamental limit is good parallelization of programs at the logical level.

The diagrams presented all show that we have reached the limits of Neumann computers and that we should be thinking about a completely different technology; quantum computers, based on different physical solutions, represent a paradigm shift.

4. Development of Quantum Computers, Their Applications

4.1. Fields of Application

The last decade has witnessed a breakthrough, with news of the development of quantum computing, the impact of which will be felt in various fields. In addition to the leading powers, countries such as Australia and Switzerland are investing huge sums of money in their development. The aim of these developments can be divided into four main areas.

The first, and most widely known, is to multiply today's computing power, on the basis of which today's supercomputers could in the future be replaced by quantum machines. The computing power that can be achieved could be applied to a wide range of fields, from improving the efficiency of weather forecasting to scientific research [59].

Another popular application area is materials and drug discovery, in general, any research area where high computational power could be used to replace or reduce the practical execution and testing process [59].

The quantum internet could represent a leap forward in today's networking technologies, based on the possibility of communication-based on the interconnection of entangled quantum bits. This, in addition to the realisation of a super-fast Internet connection, makes it clear that the confidentiality of the transmitted data is not compromised.

The fourth direction of development is to improve the quantum computer itself, the construction of which still poses a number of problems today.

4.2. Physical Solutions

Without a basic understanding of quantum physics, a precise understanding of the physics of a quantum computer is quite difficult, and sometimes even its programmers do not have a full understanding of it. Such a machine can be built based on a number of different physical phenomena, ranging from the polarisation of light [31, 46], and the spin of an atomic nucleus [6, 37] to the position of electrons.

Since most machines can be maintained at temperatures around absolute zero for a few seconds at most, there is still a lot of research going on to find a better physical base with more favourable properties.

4.3. Basic Concepts

Quantum is a Latin word meaning quantity, the plural of which is quanta. The word was introduced into physics directly from Latin by Max Planck, in 1900, with the concept of the "minimum quantity of an existing quantity"; Einstein confirmed it in 1905. Quantum theory dates from 1912 and quantum mechanics from 1922. It is the smallest possible unit in physics by which the value of a measurable unit can be increased [62]. It is usually applied to the properties of atomic or subatomic particles such as electrons, neutrinos or photons [44].

The machine works on the basis of the so-called qubit, which is the elementary unit of the machine and is most similar to, but significantly different from, the bit of a conventional computer. While a bit can have only two values (zero or one), a qubit can have these and any value in between, even simultaneously, in the so-called superposition. In superposition, the quantum particles are in a combination of all possible states at the same moment in time, but with different probabilities, which allows a quantum machine to compute many values at once. Thus, some sources say that a 30 qubit machine would have the performance of today's fastest supercomputers. The difference between a binary position and a superposition can be illustrated with a coin, for example. Binary states (heads or tails) are easy to understand. A superposition, on the other hand, is similar to flipping a coin and having it spin continuously. In this case, any value can be the result, at each instant of time it takes a certain percentage (amplitude) of the possible values, so a certain percentage for heads and a certain percentage for tails. To use another example, if we are looking for the result of a calculation with, say, integers 0-9, each value can be the solution with a certain percentage certainty at any one time. The outcome will be the one that yields the highest probability on a sustained basis, thus the percentage will peak there.

The difficulty in quantum informatics is that quantum particles are constantly changing, and fluctuating until they are measured. So qubits are extremely sensitive, and one of the most disadvantageous consequences of this is that their state can only be read out once, after which the value stored in them is lost. In addition to superposition, quantum particles have another very interesting property: entanglement. When qubits are entangled, they form a single system and interact with each other. Measurements from one qubit can be used to draw conclusions about the other and vice versa. When you add more qubits to a system by entanglement, the computer can compute infinitely more information and solve more complex multi-variable problems. For this reason, this technology is good for calculations where many factors, effects or components need to be considered simultaneously and their interactions are taken into account. Entanglement can be used to correlate the measurement results of individual quantum particles and this property can be exploited to excellent advantage in quantum informatics.

Quantum interference is the behaviour of a qubit, due to its superposition property, which can be used to influence the probability of coincidence with one or another value. One of the major challenges in creating quantum computing machines is to reduce interference as much as possible for more accurate results [43].

Several technologies are used to achieve this goal, all of them aiming at stabilising the quantum particles by manipulating their structure, for example by cooling or by surrounding them with chemical compounds that protect them from external interference.

Quantum computers exploit special forms of quantum physics behaviour in computing, such as superposition, entanglement and quantum interference. All these bring new ideas compared to traditional algorithms and programming methods.

5. Quantum Algorithms

Theoretical research on quantum machines has already made significant progress in the 1980s. David Deutsch devised versions of logic gates adapted to quantum machines [18], and in 1994 Peter Shor published one of the most famous algorithms [60], which can fundamentally challenge the data security of systems in use today.

5.1. The most important quantum algorithms

The Deutsch-Jozsa algorithm [16] was the first quantum algorithm that, in addition to revealing the potential of quantum algorithms, was able to determine a bit-parity function faster than classical algorithms. The unknown logic function expects a single bit as input and returns a single bit such that either all input bits are even or all input bits are odd. The algorithm can be used to determine the nature of the unknown function in a single quantum measurement.

The Bernstein-Vazirani algorithm [21] allows the analysis of more complex problems and functions than the previous one (Deutsch-Jozsa algorithm). The function f is given by $f(x) = a_1x_1 + a_2x_2 + \dots + a_n{*}x_n + b$, where x is the n-bit long input, a_i is the weight on x_i, and b is a constant. The algorithm can be used to determine the values of a_i and b in a single quantum measurement.

The Grover algorithm [30] is an optimized search algorithm for unordered sequences that is $2^{(n/2)}$ times faster than classical search methods.

Shor algorithm [60] is actually an optimal algorithm for factorization.

Simon algorithm [15] is a bit-parity algorithm that can solve the problem with much lower energy consumption and in less time than classical algorithms.

The Harrow-Hassidim-Lloyd (HHL) algorithm [32] is an algorithm for solving systems of linear equations that requires less memory and is much faster than classical algorithms for similar tasks.

The VQE algorithm [14] is a hybrid algorithm based on quantum mechanics that can be used to determine optimal balance states.

5.2. Encryption algorithms

Currently, widely used encryption algorithms are based in large part on the mathematical problem of prime factor resolution[1]. The protection is provided by the multiplication of the huge prime numbers generated by the process, which makes it virtually impossible to compute the prime numbers in a conventional computing environment.

Algorithm	Typical usage	Sustainability
AES	Encryption	safe with a longer key
SHA-2, SHA-3	Hash creation	Longer output is needed
RSA	Digital signature, key matching	Insecure
ECDSA, ECDH	Digital signature, key exchange	Insecure
DSA	Digital signature, key exchange	Insecure

Table 1: Usability of encryption algorithms in the post-quantum world.

Edited by Ferenc Koczka.

[1] a mathematical.

Shor's quantum algorithm solves this problem: it performs a prime factor resolution of a number at extremely high speeds, making some IT systems protected by algorithms based on prime factor resolution insecure[2]. Although in some cases the algorithm itself remains usable by modifying the operational parameters, e.g. key sizes, in practice these modifications can often only be made by the developers of the individual systems. The protection capabilities of today's most common crypto algorithms in the post-quantum[3] world are described in the table above.

Shor's algorithm is just one example of the paradigm-shifting impact of the quantum machine, and algorithms that can withstand the massive computing power of the quantum machine need to be found and incorporated into current systems. In the third phase of research conducted by the US National Institute of Standards and Technology (NIST) Computer Security Centre, several quantum-safe algorithms have been published that provide solutions for everything from hash fingerprinting to electronic signatures. Hungarian legislation has also started to address the problem, and as a result, the requirement for state and local government bodies to prepare for the use of post-quantum algorithms was included in the 2013 Act L. Although many organisations, such as businesses and educational institutions, are not covered by the law, owners and operators will have to take into account the potential exposure of their systems in the future.

Despite current developments, it is unlikely that quantum computers could replace the computers in use today. In addition to the technical difficulties, their scope is extremely limited and they cannot run regular or business-related software. However, the accelerated pace of development makes the emergence of this technology in the training of programmers, physicists and in general education, obvious.

6. Education

Not only is it important for people watching the news to be aware of these new computers, but it is also worth thinking about how the subject could be integrated into education.

to prepare society for the emergence of quantum computers and the changes they generate. Many specialists will be needed to operate quantum computers. Without them, it will not be possible to prevent and manage the potential damage they can cause, to maintain data security and to carry out the research and development that quantum computers can support. For example, training in physics, data protection, research and development in the field of quantum computing, and programming are all strongly linked to the construction of quantum computers.

Similarly, the preparation of specialist training is important, so some concepts may be worth introducing in the upper grades of secondary education. It is important that young learners should not be left to their own devices with questions, but should be able to find out about the substance of the subject and its context from a credible source, filtered, organised and processed by teachers.

6.1. Are We Late?

Regardless of how advanced quantum computing is at the moment, the question must be asked: are we too late in teaching it? The statement encoded in the question could be too strong, but it is actually true if the trend of progress in this field over the last 15 years continues at the same

[2] Shor's algorithm can be run on a six-qubit quantum machine, which has been available for years.

[3] The post-quantum refers to the era of computing in which quantum computers are expected to be used.

intensity. It is well known that quantum computing has a history of almost 70 years, but in the mid-2000s some significant progress was made. Exactly what that was is neither our purpose nor our responsibility. Let us say that it was a series of events that led to the fact that today there is so much competition between the various technological giants [11] in this field that articles and news about new developments and achievements appear almost every week or month. Let's look at the reasons why we are afraid we have missed something!

One reason is that we have witnessed an exponential explosion in the development of this new area of IT over the last 15 years. In classical education systems, it takes at least a decade for age-appropriate and target-group-specific subjects - from primary school to higher education - to appear and be integrated into curricula, from exposure to the subject in lower grades to the foundation of the curriculum. What makes integration into the curriculum even more difficult is that, in addition to IT skills, this area requires a high level of knowledge of chemistry, quantum physics and mathematics, and, unlike in the past, a much more complex problem-solving ability [3]. The problem is that recent graduates in higher education have not been prepared to take on this new field and pass it on to future generations.

Where is quantum computing now? Today, a large number of quantum computers [34, 67] and simulators [13] are available to try out and write quantum programs [35]. There are many online courses [12, 20, 65], tutorials [42, 51, 67] and animations available to demonstrate quantum computers working on different principles.

6.3. Primary School

With the recent digital transformation, information technology permeates almost every aspect of life, and children are increasingly exposed to concepts such as embedded systems, Big data, IoT, artificial intelligence and quantum computing. We would like to ask some thought-provoking questions for this age group:

- Should quantum computing be taught in primary school?
- Is it viable to talk about this field in primary school?
- What does quantum computing mean for this age group?

Quantum information science is already mentioned in the media on a daily basis with some kind of preconception. Unfortunately, it is quite often presented in a negative light, as a life-changing and life-affecting technology that cybercriminals can use to hack into computer systems, even those that protect bank accounts. This type of negative news can create inner tension and questions in children, to which they expect reassuring and exhaustive answers. We believe it is important to prepare IT teachers for these kinds of questions, to be informed and to be able to give professional answers. They should not only answer questions with negative emotions but also be able to explain that quantum computing offers new ways of secure data transmission, opening up new avenues for simulations, revolutionising pharmaceutical research, developing new materials, making meteorological forecasts more accurate and valid over time, etc. Quantum technology is therefore both an opportunity and a risk for society [10, 58].

The primary aim of IT education is to provide the right basis for navigating the digital world. There is a consensus in research on IT education that, rather than focusing on short-term technologies, more emphasis should be placed on teaching basic concepts, algorithms and principles. [2, 48, 64].

We believe that today's computer science teachers need to be familiar with the basics of quantum computing in order to be able to inform children in public education about the developments in this field; it is, therefore, inevitable that it should be part of the university education of computer science teachers.

We also believe that it is inevitable that, in time, quantum informatics will be mentioned in primary school curriculum for upper secondary school students. This age group is already confronted with the term "quantum" in the media on a daily basis, not only with the quantum computer but also with the quantum mobile phone, for example. We should explain to them what the word quantum actually means, and what physical phenomena quantum computers are based on, help them to imagine how they work, understand their purpose, understand the concept of quantum bits, and make them understand the scale and potential of quantum computing, even if it is not necessarily easy for an adult teacher of the subject to understand.

Still, we feel it is important that they are introduced to the concepts and know what the word quantum refers to. Moreover, it would also be a goal to be able to recognise and filter the content of advertisements, to see that the products advertised often do not contain real quantum computers, but merely devices with a kind of "quantum" characteristic. Just like a vacuum cleaner that has no artificial intelligence, which does not undergo a learning process, but can only stop a few centimetres in front of an obstacle using an infrared sensor. One important goal of education is to learn to think correctly about a problem.

6.4. High School

While the 10-14 age group can only be introduced to basic concepts, the secondary school age group can be provided with a deeper theoretical background. An adequate background in mathematics and quantum physics is a prerequisite for the transfer of theoretical knowledge. A number of studies confirm that the introduction of quantum computing into primary and secondary school curriculum is not only possible but necessary [3, 25, 33, 45, 47, 57, 58, 67].

Stadermann and colleagues [61] analysed quantum physics curricula and syllabuses in 15 countries from different perspectives. Quantum physics subjects at the secondary school level have only recently appeared in national curricula and their integration has been far from seamless [3]. The main content elements are designed to give students an insight into modern physics and its applications and to enable them to discuss the nature and aspects of the discipline. Common elements in the curricula of the countries surveyed include discrete atomic energy levels, interactions between light and matter, wave-particle duality, but also Broglie theory, Planck wavelength, engineering applications, Heisenberg's uncertainty principle, and the nature of quantum physics [40]. Challenging aspects such as interpretations and epistemological aspects of quantum physics are taught in only a few countries. It is a common experience that the curricula produced are still in their infancy and are therefore not necessarily the best curricula. Most of the current ones correspond to the elements of a simplified undergraduate quantum mechanics course. Curricular innovations are time-consuming, and the development and modification of national rules is a complex and complicated process [25]. Elements [5, 44, 38, 70] that would facilitate understanding, such as philosophical aspects of quantum physics, quantum entanglement and its applications, are only included in the Norwegian and German curricula.

Anastasia Perry and her colleagues [47] created a ten-chapter curriculum for high school students aged 15-18, which was presented to them in a five-day course. The aim of the course was to create a link between secondary school and university. The curriculum was organised around the key concepts of quantum information science, namely superposition, quantum measurement and entanglement. The curriculum moves from basic concepts through quantum gates and quantum algorithms to quantum teleportation. It is important to note that a high level of knowledge of electricity and magnetism is not assumed, nor is computer programming experience required. Both before and after completing the course, participating students were asked to list as many concepts in quantum mechanics and quantum computing that come to mind. It was found that, in addition to a significant improvement over the survey written at the beginning of the course, students were motivated by the feedback to pursue physics and computer science [33].

Pashaei et al have created an online accessible courseware that can be used to effectively introduce the basic concepts of quantum computing at the elementary and secondary school level. In addition to creating a usable online curriculum, they have also sounded the alarm bell in Canada. The concepts of quantum mechanics are not part of everyday life, even though learning about them can have a positive motivational impact on students. They point out that introducing quantum physics and quantum computing at an early stage of education can contribute to the development of a society that understands the importance of science, thus bringing it to the forefront [45].

The field of quantum computing is mature and accessible to students. Angara and colleagues have reported on the results of workshops in quantum computing. They held short workshops primarily for students who had no prior knowledge or experience with quantum informatics. They took a programming-based approach, introducing students to the IBM Q Experience through Qiskit [51]. Based on their experience, they found that quantum computing concepts can be understood and processed by high school students. They also point out that their experience shows that early exposure to quantum computing develops students' problem-solving skills and expands and contributes to the competencies they need to acquire before applying to university [3].

7. Conclusion

In summary, the fundamental question is: should this area be addressed outside higher education? Can we claim that it could soon be part of education, as a mere mention in primary school, and as an introduction to concepts and the use of simulation quantum machines in secondary education, since we already see a number of examples of this abroad?

As far as we know at present, quantum computers are not expected to replace traditional Neumann computers, but the results of the last decade and a half [4, 9, 63], the plans of the tech giants [11] and national governments [26, 29] suggest that they will almost certainly become a visible segment of computing in the next ten years.

It is clear that, like all trends, it has its followers and researchers who have considerable reservations about the results and whose vision for the future is far from optimistic. In their view, it is impossible to build a general-purpose quantum computer with even the qubit needed to achieve the current computing capacity and operate within an acceptable margin of error [39].

In light of all this, we can say that both experimentation and uncertainty are outlined in the field of education. But we see that even if quantum computers remain stuck at the current level, i.e. only capable of generating well-specified subproblems and non-pseudo random numbers, they can be used to improve problem-solving ability, broaden horizons, deepen the understanding of time complexity, popularise physics or promote understanding of quantum physics [19].

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Chatbot Development using APIs and Integration into the MOOC

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Abstract. In recent years, chatbot technologies have evolved into modern information and communication technology applications that perform many virtual tasks, including learning. One of the challenges in improving the chatbot is the insufficient knowledge base of chatbots, including education-oriented conversational agents, the challenges in connecting the chatbot with course content on Massive Open Online Course (MOOC) platforms. In this study, a chatbot was developed to answer questions using publicly available technologies, specifically Application Program Interfaces (APIs) that promise convenient user accessibility via APIs, such as the Facebook Messenger platform along with wit.ai API, Canvas MOOC API, and Wikipedia API.

API technologies were used to connect the chatbot to selected course content on the MOOC platform as well as to large knowledge bases such as Wikipedia to expand the knowledge base of the Conversational Agent. The course selected for the chatbot integration was on general informatics topics. Most course participants interacted with the chatbot via the Facebook Messenger platform using their handheld devices. Thus, integrating the chatbot into a widely used platform such as Facebook Messenger is a convenient and effective way for reaching learners. The API technology enabled an efficient connection between the chatbot and third-party apps, including the Messenger app, wit.ai, Canvas MOOC, and Wikipedia. This was due to the variety, richness, manipulation capabilities, and format of data that an API can transfer. In addition, the Wikipedia API seemed to be a vast source of information for expanding the chatbot's knowledge base. Not all of the queries posed to the chatbot were part of the course content. Some participants questioned the personality of the chatbot and were curious about the persona of the conversational agent. This suggests that a chatbot that has been endowed with some personality traits is stimulating and more likely to be accepted by learners.

Keywords: Chatbot, Conversional Agents, Pedagogical Agents, Intelligent Agents, API, Canvas, MOOC

1. Introduction

Technology has changed the way people communicate and interact. One of the rapidly emerging innovations is the development of chatbots or conversational agents. In the past year's chatbot technologies have proven to be effective modern Information Communication Technology (ICT) applications that perform many different virtual tasks [1]. Chatbots are computer agents that communicate naturally with humans using text and speech. By applying Natural Language Processing chatbot can communicate and assist the user to perform some tasks in a specific domain [2].

Chatbot applications have a long history of development. The world's first chatbot named Eliza [3, 32] was developed by Joseph Weizenbaum in 1956. It simulated a psychotherapist and aimed to explore natural language and communication between humans and machines. Since then, the use of chatbots has increased greatly and there are estimates that their use will increase even more in the coming years [5]. With the advent of artificial intelligence and the development of natural language techniques, the use of chatbots has expanded to a variety of fields, including medicine [6] customer service [7, 36] banking [35] personal assistance through smart speakers [8], and educational applications [9]. In general, chatbots can be divided into task-oriented and open-domain chatbots [10]. Task-oriented chatbots are designed to perform a specific task such ordering food or booking tickets. Open-domain chatbots can carry on a conversation on a variety of topics, provide entertainment, and socialize. Open-domain agents are still in their early stages; task-oriented chatbots on the other hand, currently have a large market share [11].

In recent decades, Information and Communication Technology has significantly changed the higher education environment and the Smart Learning Environments (SLE) approach has emerged, which uses innovative technologies and artificial intelligence to enable greater flexibility, personalization, engagement, and motivation of learners [12].

The use of these technologies has become crucial as the high demand for education has recently put a lot of pressure on higher education institutions. Clear evidence of this is that the number of students per teacher is increasing [13]. This means that the support of each teacher for each student is decreasing significantly [14]. This is one of the main reasons for ineffective learning and a high dropout rate [15, 16]. Academics and managers have started offering chatbots to address these daunting challenges in the education sector. Chatbots promise to solve a variety of problems in education today [27]. One of the biggest advantages of chatbots is that they can provide students with personalized and intensive tutoring [17], which is especially useful in large learning environments at universities or in Massive pen Online Courses. The fundamental issue with chatbots is limited communication due to a lack of vocabulary and information that is incomplete or incorrect [18, 19, 20]. Due to this problem, chatbots have a low penetration rate and their use is limited to the simple dyadic conversation [21, 22, 23, 4]. Therefore, future research should focus on expanding the knowledge base and turning the chatbot into an open educational resource [24, 25]. Most studies on chatbots in learning have been conducted in controlled experimental settings [26, 27, 28]. We need more research that focuses on the integration and use of chatbots 'in the wild', i.e. in the original environment of Massive Open Online Courses.

Our research question is to investigate the potential of using current online communication technologies to develop a chatbot and connect it, on the one hand, to massive knowledge centers that enable real-time communication and data transfer between chatbot and these platforms, to expand the knowledge base of the conversational agent, and on the other hand, to integrate the chatbot in real-time with course content on a MOOC platform so that the chatbot can respond to course-related questions from users using these communication methods and explore the possibility of deploying the chatbot on these platforms.

With respect to the research questions in this study, we will use publicly available technologies to develop a chatbot utilize application program interfaces (APIs) to connect the developed chatbot to course content on the MOOC platform as well as to large knowledge bases such as Wikipedia to expand the knowledge base of the conversational agent. Web APIs, also known as representational state transfer (RESTful) services [29] when they conform to the architectural principles of REST [30], are characterized by their relative simplicity and their natural fit for the Web. Based on this simple technology, many websites such as Facebook, Google, Wikipedia, and Twitter offer user-friendly public APIs that provide easy access to some of the resources they offer and allow third parties to combine and reuse heterogeneous data from different services. We will apply this technology to develop an online solution that connects various components of the chatbot and expands its knowledge base, where information is pushed and responses are received in a real-time.

2. Materials and Methods

2.1. Chatbot Development

There are several platforms for developing chatbots, most of which are commercial and require payment for resources depending on the package used. One of these platforms is Chatfuel. From a developer perspective, the Chatfuel service is the most commonly used platform for chatbot development [32]. When developing the chatbot, our priority was to use publicly available technologies that provide modern development, integration and communication methods.

The Facebook Messenger app was used as the initial and client-side component of the chatbot. This platform offers several free API services that can be used indefinitely. Only verification of legal use of the API services is required. Recent statistics show how heavily Facebook Messenger is used and adopted by social media and mobile device users. Every month, more than 1.3 billion people use Facebook Messenger [31] and the Facebook Messenger mobile application is the third most used app in the world, used by 68 percent of users [32]. In addition, Facebook Messenger platforms support rich media, such as images, animated Graphics Interchange Format (GIFs), and videos. Therefore, we assume that this platform can provide a convenient input or messaging channel between course participants.

The wit.ai API was used as the Natural Language Processing (NLP) engine for the chatbot. Wit.ai is an open and extensible NLP engine for developers that was acquired by Facebook. It is a free software-as-a-service (SaaS) platform that provides a simple user interface and fast-learning APIs to understand human communication in every interaction and helps decompose the complex message, whether speech or text, into structured data (intent and entities). Wit.ai provides a Graphical User Interface (GUI) that facilitates the creation of efficient and powerful text or speech-based conversational bots that humans can interact with.

To connect the chatbot to the selected course content available on the Eotvos Loránd University MOOC platform, the Canvas API was used with multiple endpoints to retrieve specific information about the course in each case. The Canvas MOOC and Learning Management System (LMS) provides a REST API for accessing and modifying data outside of the main application using code and scripts. This allows data to be easily transferred between these platforms as well as external applications. An access token is required to access the Canvas API and the API authentication process is done through OAuth2. Several Canvas APIs were used to retrieve various information about the course and its content, such as the Courses API, which was used to answer questions such as course start and end dates, course name, course modules, course announcements, and participants, etc. This information was dynamically generated from the course attributes on Canvas MOOC and sent to the chatbot server via the API to answer users' questions.

The knowledge base of our chatbot was extended by using the Wikipedia API with its various endpoints. For example, the Wikipedia search API to search for the forwarded term, to check whether it occurs in Wikipedia or not, and to find the most related terms. Also, the Wikipedia summary API generated a summary and an image of the found term, if one was available.

The answer generation component worked in such a way that if the answer to the user query was not found in the course content, the questions were sent in structured data to the Wikipedia knowledge center via the API. In general, Wikipedia API answers were structured in the form of a summary of the term with an image, if available, and four randomly selected related terms for which the user could also submit a query.

Figure (1) illustrates the general structure of the chatbot, which consists of different components. In each component, different technology has been used. The connection between all the components is made through API technologies including Messenger app API, wit.ai API, Canvas MOOC API, and Wikipedia API. The user interface of the chatbot is managed by the Facebook Messenger app. From this component, the user begins interacting with the chatbot, either through the Facebook Messenger platform or through the chatbot plugin that makes the chatbot accessible on the selected course page of the MOOC platform. A Page Access Token and an App Secure Token are used to connect the Facebook Messenger app to the chatbot webhook (server). The chatbot webhook or server was implemented in NodeJS and JavaScript programming technologies. This component was responsible for forwarding the user messages to all other components and sending the response message to the Facebook Messenger app. From the chatbot server, the received user message was first sent to wit.ai, the NLP component of the app, to generate structured information from the user messages by detecting the intent and entity. wit.ai sent the structured information back to the server via the API. This data was used to generate the answer message by first sending it to the course content on the MOOC platform via the Canvas API and database to search for the answer. The process of searching for answers is based on structured information received from the wit.ai NLP unit via the API. Once a relevant answer is found, the server sends it to the user via the Facebook Messenger interface. In case no matching answer could be found in the course content and database, the data was sent to the Wikipedia knowledge center to search for a matching answer. The chatbot responded with a default message generated by the chatbot's server or the webhook if there was no matching answer based on the structured data entity.

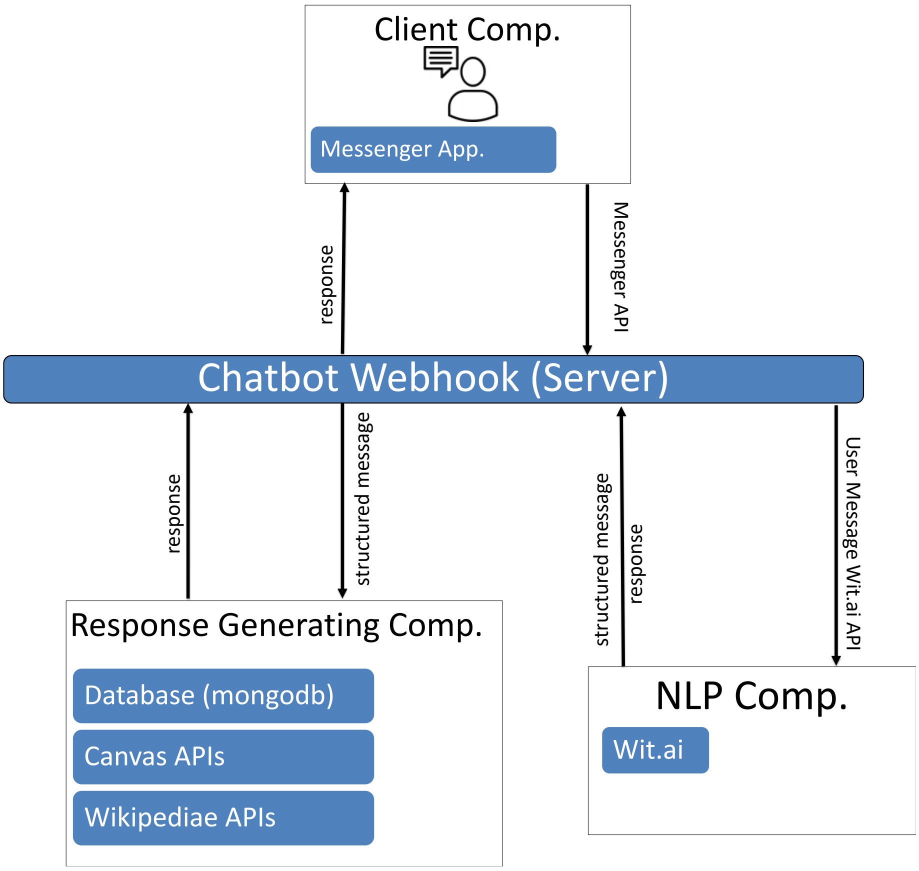

Figure 1: General Structure of the Chatbot

2.2. Course Selection and Data Training

After developing the chatbot using publicly available technologies and APIs, the next step was to select an appropriate course and integrate the chatbot into that course. The course we chose for this purpose was the popular Experiential Informatics course on the Canvas MOOC platform of Eötvös Loránd University, which was open to the general public in the Hungarian language from June 10 to August 31 in the summer of 2021. It enables practicing teachers to increase their motivation with fun Information Communications Technologies tools, students to experience the diversity of computer science as a profession, parents to discover apps that facilitate learning, and anyone interested in the wonders of informatics to learn in a community.

From the selected course content, 316 question-answer pairs were generated by going through each model of the course and identifying the possible questions students might ask. This dataset was used to train wit.ai, the NLP component of the chatbot, with the course content. Based on the questions generated in the dataset, different intent categories were created in wit.ai, such as *get_course_info, get_defention, get_module_info*, etc. For each question, the intent and an entity were detected by wit.ai. The most important part of the structural information created by wit.ai was the resolved value of the identified entity in the question since the answer generated by other components depends on this value.

2.3. Data Analysis

For data analysis, we technically monitored the app log to analyze user messages to the chatbot and the conversational agent's response to user messages. To incorporate user feedback regarding the chatbot response to their message, each chatbot response was assigned a question asking the user if they were satisfied with the chatbot response to that particular question. The user could choose the option YES or NO.

The Messenger Analytic App and wit.ai Insights were used to analyze the interface through which the user interacts with the chatbot and the user's satisfaction with the chatbot response. In addition, these analytics tools were used to investigate the source of the chatbot response, e.g., to determine whether it came from the Canvas MOOC APIs used to connect the chatbot to the selected course content, or whether the response came from the Wikipedia APIs.

Due to the outage of the Facebook social network and its affiliate apps on October 4, 2021, and the discontinuation of the Facebook Analytics app process, [37] there were difficulties in efficiently retrieving the expected data from Facebook Messenger Analytics.

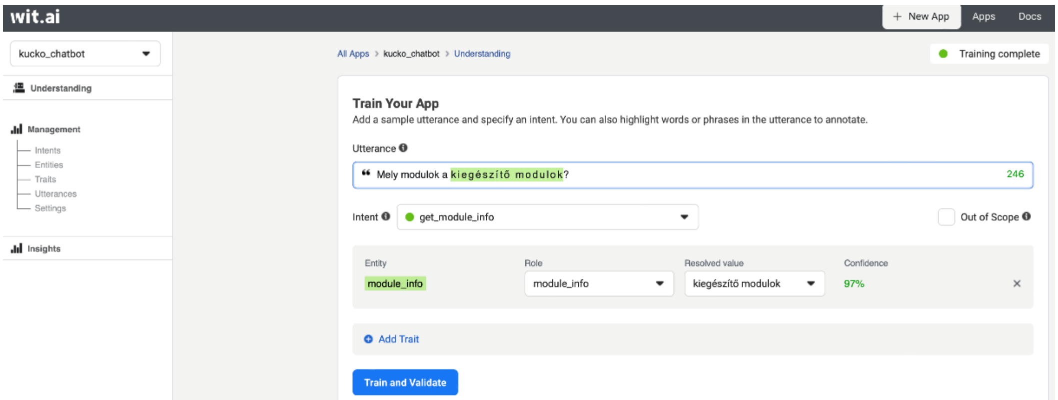

Figure 2a: Wit.ai Data Training Examples

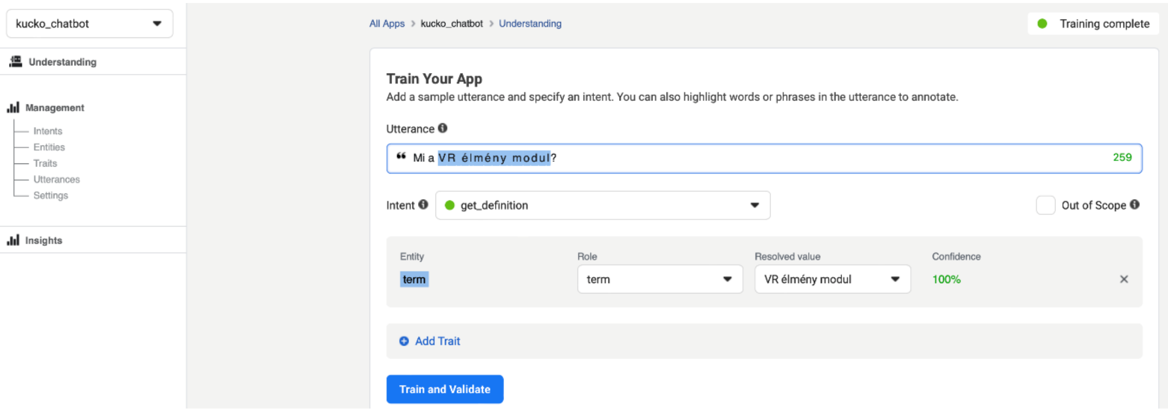

Figure 2b: Wit.ai Data Training Examples

3. Results

The result of the data collected and analyzed from the time the course was running shows that there were a total of 214 individual interactions and engagements between different course participants and conversational agents. Of these, 149 used the Facebook Messenger app to initiate an interaction and conversation, representing 69% of the total number of interactions. On the other hand, 65 other interactions, which accounted for 31% of all interactions, were initiated through the chatbot plugin, either through the course page on the Canvas MOOC platform or through the chatbot plugin on the website developed specifically for the course. This indicates that most students engaged with the chatbot through the Facebook Messenger platform using their handy devices.

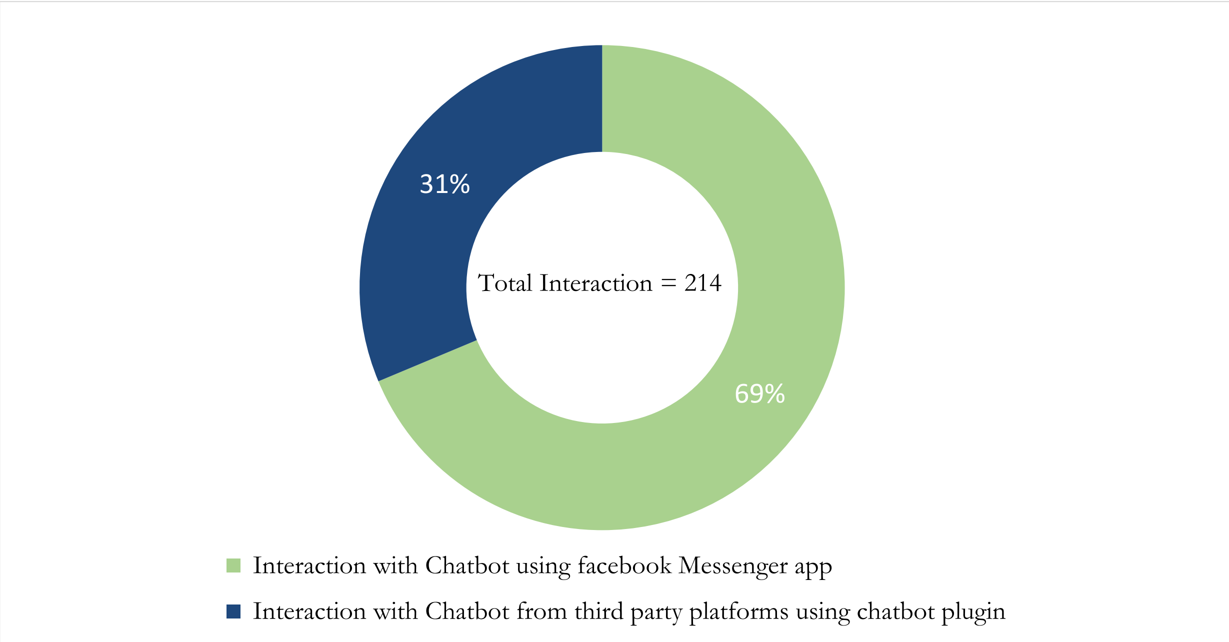

Figure 3: User Interaction with the Chatbot

The above number of interactions yielded a total of 418 unique utterances, although this number could undoubtedly be higher if we counted duplicate utterances, as the same utterance or question could be asked by different users. Participants identified 286 conversational agent responses to these utterances as correct responses, representing 68% of the total utterances. The remaining chatbot responses were either identified as inaccurate or not reported back by the participant.

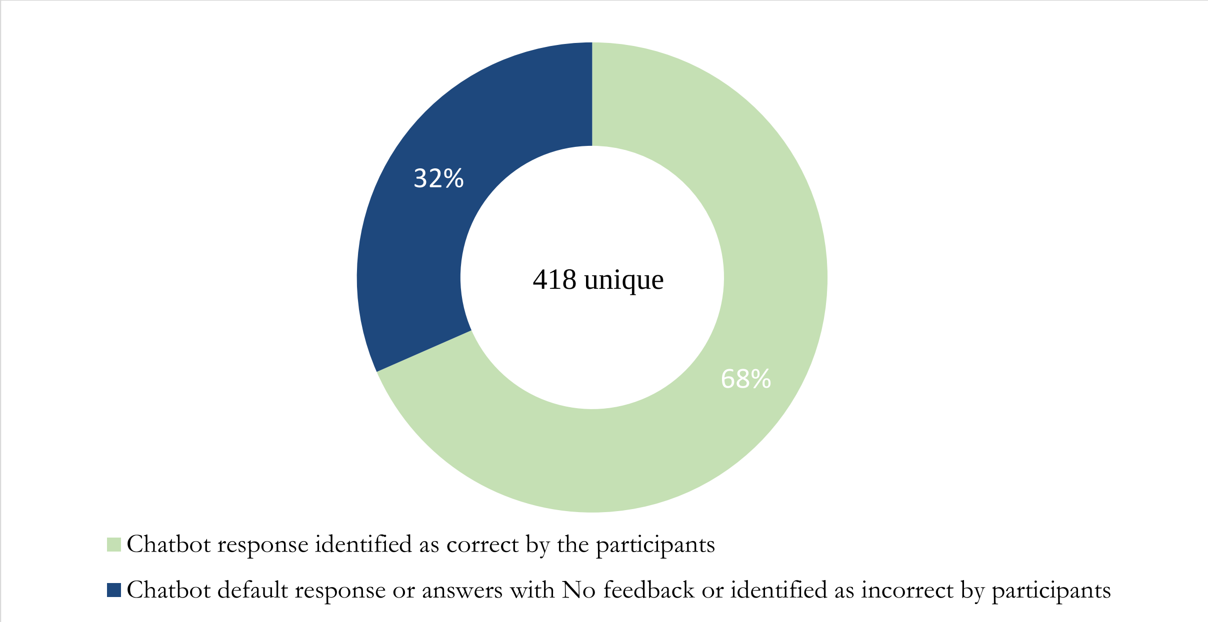

Figure 4: Users Feedback to the Chatbot Responses

Regarding the source of correct chatbot answers, 60% of all correct answers given by chatbots to participants' questions came from Wikipedia APIs and 40% from Canvas APIs used to access course materials. API technology appeared to be a reliable means of developing a chatbot and connecting it to the course. content on MOOC platforms such as Canvas and real-time information centers to expand the knowledge base of this tool.

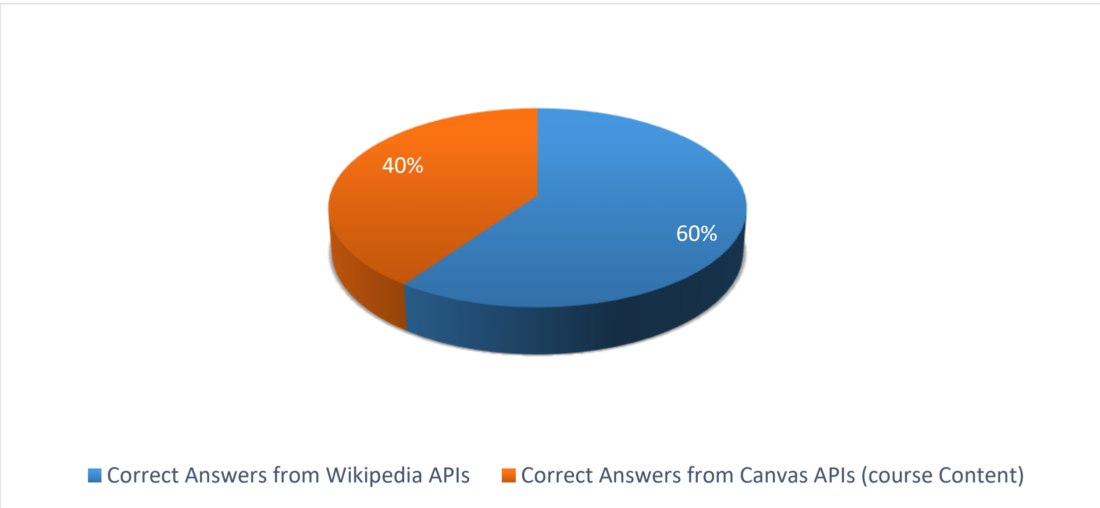

Figure 5: Source of Chatbot Correct Answer By APIs

3.1 User Satisfaction

In terms of the type of questions asked by the participants, the data analysis shows that participants did not always ask course-related or general information questions, but also questions about the personality of the chatbot. In other words, students expect the chatbot to be a socializing tool in which they can communicate with and satisfy their social needs, not just an educational agent. This is consistent with other research suggesting that chatbots' ability to convey empathic emotions, support life skills, and self-disclosure will lead chatbots to be a promising source of everyday companionship, rather than being perceived as cold, socially awkward, and untrustworthy [33, 34, 28].

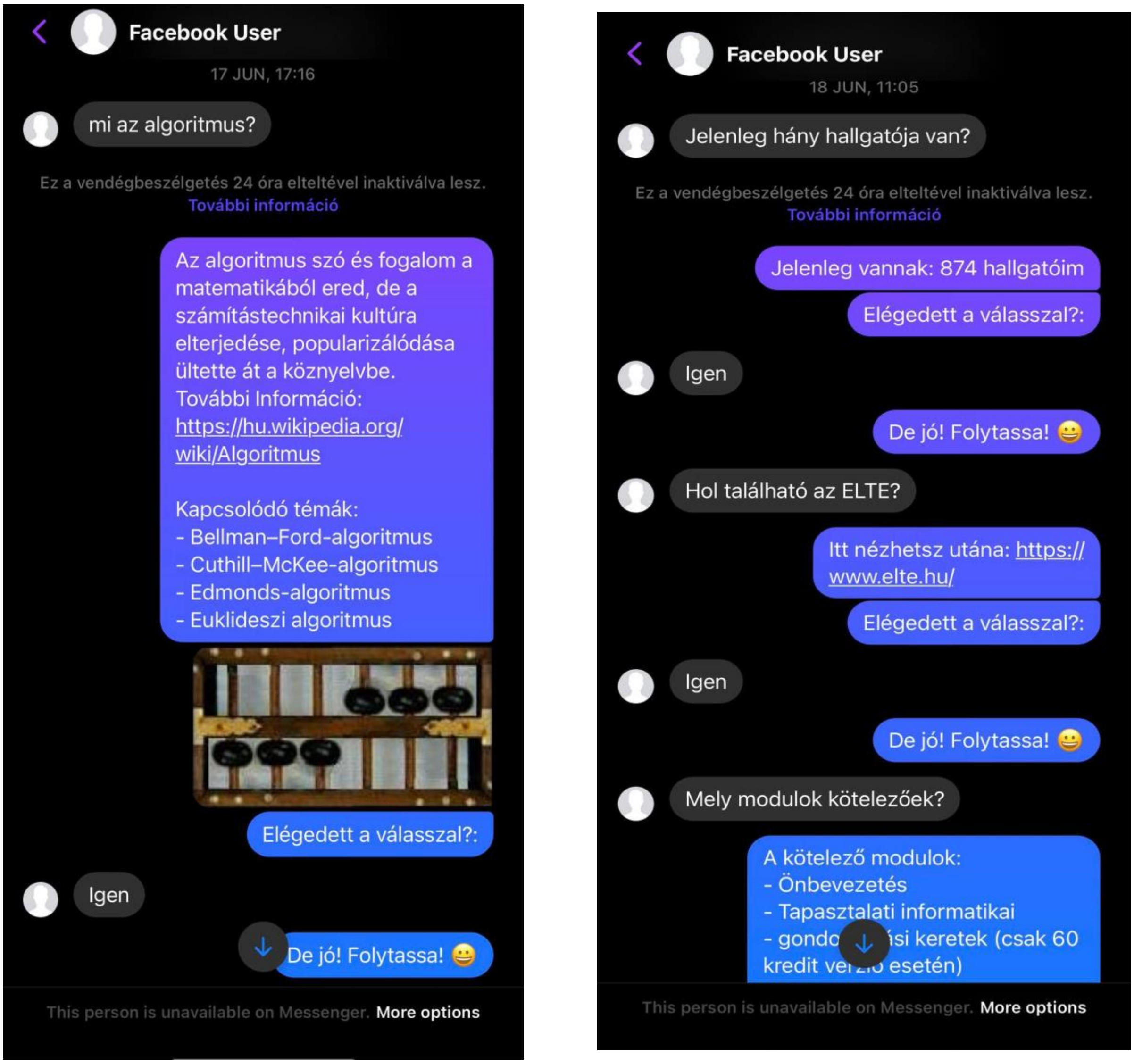

Figure 6a: Examples of User-Chatbot Messaging

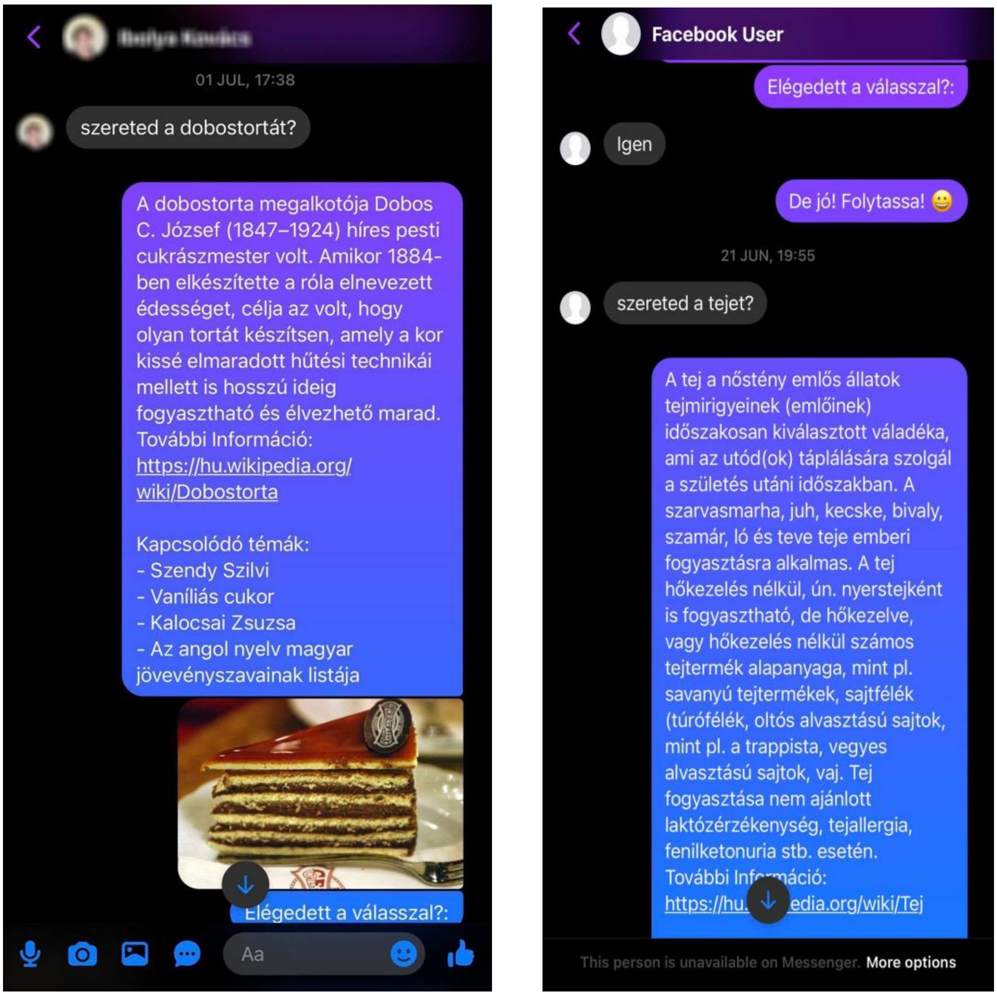

Figure 6b: Examples of User-Chatbot Messaging

4. Conclusion

The availability of sophisticated methods to access chatbots is essential for the constant and convenient use of chatbot technology. In this study, we used the Facebook Messenger platform to integrate the chatbot through an API, which proved to be a well-accepted and user-friendly platform for interacting and messaging with the chatbot. It was observed that most students engaged with the chatbot through Facebook Messenger, utilizing their portable devices, emphasizing the convenience of this platform.

The API technologies enabled robust connectivity and data exchange between the chatbot and course content on the Canvas MOOC platform on the one hand, and third-party applications such as Wikipedia Knowledge Center on the other. This was due to the variety, richness, manipulation capabilities, and format of the data that an API can transfer in real-time. However, the effectiveness of the chatbot's content delivery is contingent on the structure and design of the course content on the Canvas MOOC platform. The type and amount of course content that the chatbot receives depends on the nature of the data, whether structured or unstructured, and the design of the course materials. Moreover, the integration of the Wikipedia API provided a vast repository of information that was beneficial in expanding the chatbot's knowledge base.

The study disclosed that the participants demonstrated a tendency to inquire not solely about the course, but also regarding the personality traits of the chatbot. This finding implies that the in the future design of chatbots, personality characteristics of these intelligent conversational agents ought to be taken into consideration. This suggests that chatbots should be designed to provide more than just factual responses but also engage users in a more personalized and human-like manner.

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Talent Targeting at secondary school – Pilot Study

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Abstract. All students have the right to an education that is appropriate to their ability, but this is not the case in practice, either at home or internationally. Generally, public education focuses on the middle of the Gaussian curve, and deviating from it in either direction is unfortunate, especially for students with a talent for computer science [1]. The current classroom evaluation and differentiation focus on student performance, ignoring the pupil's soft skills and personality, and it doesn't try to reveal the reason for underperformance, which also could come from hidden giftedness. The first step in providing the right level of education and talent management is to identify the students concerned. To support this aim, the article presents an approach used in business. This approach integrates personal traits, and soft skills into talent searching meanwhile continuously observe classroom works beside the results. The identification of the target group, its dynamic management, and the organization of the necessary measurements into a coherent concept form the theoretical background of an ongoing experiment. The subjects of Computer Science are important for every pupil regardless of their further education, as the digital culture covered science, business as well as everyday life. Talent searching and management of Computer Science at secondary school is particularly useful for pupils as well the community.

Keywords: Talent in informatics, formative assessment, algorithmic thinking, targeting

1. Introduction

The new national core curriculum in Hungary was presented in 2020, that place more emphasis on IT education [2]. The teaching of the digital culture subject provides greater attention to the use of IT in the learning of other subjects and in supporting different disciplines. This is strongly justified by the development and change in the digital world, as information technology evolved from a computing science - that is of interest and concern to a narrow group of students - to a cultural field covering all areas of life. As with mathematics, the auxiliary science character of computer science was confirmed which requires all citizens to be familiar with digital culture. This is more than digital literacy, the EU's European Digital Competence Framework for Citizens, updated every few years, or DigComp 2.2 for short, describes the content of the digital competencies currently considered relevant for EU citizens in the form of learning outcomes [3]. Following these recommendations, the national core curriculum has increased the number of lessons and, in addition to content search and management, which reinforces the nature of assistive science, also includes a stronger emphasis on algorithmic thinking and computer problem-solving.

In managing the increased number of lessons and the expanded curricula, students have more opportunities to demonstrate their potential in a particular area, while teachers have the chance to identify new students with potential in computer science. Not just for drive all students into IT careers, or to get more students into competitions, but to ensure that those with a good aptitude for IT develop it, whatever their career choice. In many areas of life, IT skills acquired in secondary school are an advantage [4]. There are many arguments for talent selection and talent management, one of which is a statement by Franz J. Mönks, a Dutch educator: *"Every effort should be made to ensure that every pupil, whether highly gifted or poor ability, can develop according to his or her abilities."* [1/p. 57.] In other words, every child has the right to an education appropriate to his or her abilities and interests, which, unfortunately, is not the case for all students, either in national or international practice. This is particularly true in the case of students who are gifted in computer science and who sometimes outperform their teachers in a particular area. The first step in providing the right level of education and talent management is to recognize and identify the students concerned. To support this aim, the article shows a complex approach used in business [5].

2. The burden of talent

The public perception is that talent is a blessing for both parent and child. But experience shows that in many cases it is more of a burden [1]. In line with societal expectations, public education is designed to fit the middle of the Gaussian curve, and deviations from the curve (whether negative or positive) are not adequately managed by the system [1]. In some countries, this approach to the educational system was amplified by history and the dominant ideology, like in Hungary. In the years of socialism, talent management was equated with an elite education and was neglected for a long time, and when its necessity was recognized again, it met with resistance from teachers [6]. In the 21st century, national education in Hungary is trying to catch up with international standards in an organized framework, with the support of the Federation of Hungarian Talent Organizations. At the same time, movements from the United States, which have emerged from the symbiosis of the academic and political left, are also placing greater emphasis on catching up underprivileged than on talent management. In Europe, this approach has always been stronger, so gifted students are still often left to their own devices, saying they can progress without help, they easily reach the level of skills and knowledge set out in the curriculum [7].

The literature on giftedness, however, reports experiences that differ significantly from the above, as confirmed by many parents and teachers who have encountered identified giftedness. Gifted students who are not taught at a level appropriate to their ability are usually under-performers, they can easily become unmotivated, lazy, and as a result, often become impertinent students with behavior problems that disrupt classroom work. It is in the interest of both the school and the teacher that gifted students do not disrupt the work in the classroom but is cooperative, while at the same time, these students should be given the opportunity to receive an education that is appropriate to their abilities and needs [1].

In the literature on giftedness, it is primarily the promises of giftedness that are of interest from an educational point of view [7]. Realized talent is seen in only adult life when the talent provides a sustained performance over a considerable period. Whether we talk about realized or promising talent, there are several models of talent, the common points of which can be summarized as follows:

- outstanding abilities (intelligence, creativity)
- good personality characteristics (motivation, perseverance)
- good environmental conditions

Of course, there are many different views on the details of each of these components in the known talent models. However, it is interesting to note that each of the common points is influenced by the public education system, the school, and the teachers who teach the students. Ideally, teachers have a key role to play in the development of skills, and in their education, they also develop the personality of the student, thus providing the right environment for the development and growth of gifted students.

It is generally believed that high intelligence - measured by several standardized intelligence tests - correlates well with talent. Interestingly, the seven main areas of talent were defined by the factor analysis of the questions in intelligence tests, which are the next: language, music, mathematical-logical, visual-spatial, physical-motor, interpersonal, and intrapersonal [7]. Information technology is not included, and it is difficult to establish a clear relationship between specific areas of information technology and the seven known talent areas from a digital competence perspective. Algorithmic thinking and systemic thinking can be assumed to be underpinned by good mathematical reasoning skills, while creative skills benefit from an advanced level of visual and spatial perception. For many students, the use of ICT tools and applications relies on a fully automatic, bodily-motor ability, while the competence to search for and manage information relies as much on linguistic skills as on mathematical-logical skills.

Gardner identified the seven talent areas in the 1980s when computer science was just infiltrating secondary schools with the first personal computers [7]. There was no subject in which computer science education was organized, so standardized tests did not include questions to test competencies in computational thinking. It would be useful to develop newer intelligence tests that would now include components of digital competencies, following the changes in curriculum and syllabus over the last 40 years.

Abraham Maslow's work is well-known in economics, he studied people's motivation. In his view, people's actions, the motivation behind their actions, are determined by their needs. He set up a hierarchy of needs, at the bottom of which, as the most basic human need, is the satisfaction of physical, and physiological needs (food, drink, clothing, shelter, etc.), followed by the need for security, then the belonging and after it the self-esteem, recognition. When these are fulfilled, one can move on to the higher needs of understanding the world, aesthetics, and harmony level, and finally, at the highest level, self-actualization [8]. Maslow's hierarchy of needs has not been validated and is disputed by many because of the methodology used. Maslow involved specifically successful, talented people in his research, so he looked at presumably motivated people. This warns that it is not only successful people who should be interviewed [9]. In business, it is possible to focus only on success, but in education, it is important to analyze failure and its causes in order to reduce the rate of failure.

3. Giftedness in information technology

Since the talent models and available talent tests do not focus on IT talent promises, an important question is: who can be considered talented in IT? Someone who has been programming since kindergarten. If such a child exists, he or she is probably gifted, but more general, measurable criteria are needed. There are, of course, professional recommendations on what skills and abilities should be present at a given age. For those students who are 2-3 years ahead of their age group, there is a presumption of potential talent [1][7]. In addition to the literature on giftedness, several studies [1][10] have demonstrated that children, following the parental model, can have additional knowledge in the area of competencies related to the activities their parents practice from an early age. In the case of IT, more and more parents are nowadays using computers in the home, so children following this model can also learn about computers as soon as possible. The motivation to learn about computers is reinforced by the entertainment content, games, and videos on computers, which now offer greater freedom of choice and interactivity than television. However, it is questionable whether watching videos and playing games is an indication of potential IT talent or it displays merely a motor fixation on the steps needed for entertainment. It should be noted, however, that for many children, computer entertainment is a motivation to learn computer use and other related skills and may therefore be a gateway to a community of IT talent.

In the literature, there are many approaches to searching for and identifying IT talent and talent promise, as to what students should know and in what areas they should excel. Ionica-Ona describes technological talent as *"the expression of the superior endowment in different areas of the technical field, as the excellence, demonstrated by an outstanding performance in this field or as a potential of excellence demonstrated by the results in various forms of evaluation."* [11/p. 2.] Another approach is the EU's definition of digital competence, which provides a hierarchical set of skills and competencies [3], including application skills, and algorithmic thinking for programming [12][13]. Computational thinking is also widely used in the international literature, but it is as difficult to define as talent, as it is one of the youngest disciplines and fields of knowledge and is developing very rapidly [14]. However, the main components of computational thinking, such as decomposition, pattern recognition, abstraction, generalization, and algorithmic thinking, and those components can be highlighted as they are measured by tests.

Thus, to identify IT talent, we cannot use a single well-established test, but by using tests from multiple approaches, we can gain insight into the knowledge and competencies of individual students in the given area of IT.

4. Digital culture education

The NAT2020 curriculum currently in force in Hungary, considering the EU key competencies, recommends the use of IT tools in almost all subjects in order to help students reach the appropriate level of digital competence [2]. Mathematics subject requires the use of computer games and programs to develop mathematical skills by the end of grades 1 to 4 in addition to solving mathematical problems by computer. The use of games to develop mathematical skills is a curricular requirement even for the next age group of 10-14 years. The digital culture subject starts in grade 3 when the primary aim is to develop an appropriate attitude to the use of tools, supported by creative work and the use of drawing programs. In addition, they are introduced to the basics of coding through the control of age-appropriate robotic devices. In the upper grades, the aim is to learn how to use common office applications and learn the process of algorithmization through robot programming. Students entering secondary school will thus already have measurable knowledge in the main areas defined by the EU Digital Key Competences.

As many students have learned about computer science through games, many of them have become enthusiastic and motivated to learn IT, and this momentum should be used in education. On the other hand, some students have lost their motivation or never had it. As the new digital culture subject proposes the use of IT tools to support the teaching and learning of other subjects, this can help to develop motivation and interest in IT for students, who are engaged in other subjects.

In the classroom, of course, the aim should be to ensure that as many students as possible are active participants in the lesson. The teacher must give pupils tasks that match their interests and abilities and are able to arouse their curiosity. In task-solving activities, the teacher has the opportunity to observe the problem-solving skills and abilities of individual students, and through these gain insights into their thinking. Students who are either faster than average or who have more unique and interesting solutions than the others should be invited to a specialization, which gives the teacher more opportunity to identify potential talents and nurture them.

5. Statistical approach

There are known and lesser-known difficulties in talent identification, some of which are highlighted here [1][7]:

- Existing talent tests can help identify gifted students, but a test, or even a series of tests, may not be sufficient to identify a gifted student.

- Psychological tests can also help to identify gifted students, but, like talent tests, they investigate pupils' endowment only once, on a given occasion.
- Teachers can observe their students on a continuous basis, but in most cases, they have to give students tasks that students of average ability can do, again reducing the chances of identifying students of outstanding ability.
- The special classes offer a good opportunity, but students apply for these on the basis of interest and motivation, which again reduces the possibility of identifying potential talents, as students with insufficient self-awareness and self-confidence usually don't join these courses.

Based on the back-track algorithm, leaving aside the difficulties, let's step back and look for another possible path. Let's start with an estimation, an approximation, of how many students in a secondary school can be gifted. The gifted pupils should not be confused with pupils, who get straight excellent marks. It is well known that there is considerable variation across secondary schools, with most secondary schools seeking to recruit the best-ability students and create homogeneous classes in terms of ability [15]. Despite the homogeneous classes, there are differences among pupils' abilities based on the Gaussian distribution regardless of their marks and test results [15]. Exploring these differences and to understand the reasons behind them is part of the talent search task, as it helps to find more and more potential talents.

The various talent models give approximate estimates for their models of what percentage of a given age group might be talented according to the model. Given that different models created by different experts used different definitions of giftedness and different characteristics, it is not surprising that the proportion of students in the age group who were assumed to be gifted was estimated differently. Terman (1925), who used intelligence tests to measure talent, estimated that the top 1% of the population might be gifted; Robinson (2005) estimated the top 1-3%; Brody and Stanley (2005) estimated the top 3%. Freeman (2005) sees the top 5-10%; Gagnè (2005) the top 10%; Gordon and Brigdlall (2005) see the top 15% of the population as gifted; finally, Renzulli (2005) sees the top 15-20% of the population as gifted. Terman's and Robinson's models are more specific, while Renzulli has a more general model. As we focus on searching for potential talents, it seems better to select the widest range, 15-20% of students rather than the 1% [7].

Economics also can help to choose the right ratio, as there is a rule of thumb, which was created by Vilfredo Pareto in 1906. Based on his observations of the unequal distribution of wealth, he created the 80-20 rule, whereby 80% of the wealth produced goes to 20% of society. Joseph Juran (1940) made a similar observation in the field of quality when he recognized that 80% of problems are caused by 20% of the mistakes made [16]. Later, the Pareto principle became general in economics and management science, and it is commonly called the 80-20 rule. As is a rule of thumb, important to note that the exact rates are different, that only approach the 80-20 values. The most well-known statement is 80% of the turnover is generated by 20% of the customers, and 20% of the sales generate 80% of the turnover [17]. Nowadays Pareto-principle is also used in Computer Science as well as education [18].

The common application of the Renzulli Talent Model and the Pareto Principle is worth considering 20% of students as potential talent. On one hand, Renzulli's model contains the widest range among the well-known talent models, which means he supposed the most potential giftedness within an age group. On the other hand, based on the general meaning of the Pareto principle can be supposed the best abilities characterize the 20% of pupils in an average class. Which students should be included in the 20% and which in the 80%, and how final these choices are, is also a question that is worth following a method used in economics.

6. Application of targeting at the secondary school

In the business world, marketing is about identifying and engaging potential customers who are the target audience. Targeting is the process that defines the target group. An important aspect of targeting is the application of the Pareto principle. The primary task is to find the 20% of customers who generate 80% of the turnover. In the business world, this is easy to determine from sales data in most areas. In addition to the current and previous traffic data, it is useful to know the potential of the target group, and whether the known traffic can be further increased. On the basis of this information, businesses can modify their marketing activities and messages, increase or modify their resources, or even target other customers.

Differentiation is used in education for similar purposes. Keeping students of different abilities and interests motivated and stimulated requires different tasks. In most cases, differentiation is based on the teacher's observations of the lesson and the results of students. For a more effective application of differentiation, targeting, which is used in business, can provide useful information, as it focuses on opportunities and customer potential. By considering the similarities and differences between business and education, a model can be developed to test the use of targeting in education.

Talent potential is the promise of an individual student's talents, and it is generally an unknown variable in public education. Student performance, which can be compared to business turnover, fluctuates. For more accurate modeling, we can choose a narrower slice of the business world, where, as in the school environment, there is also limited information available. One such business is the pharmaceutical industry where, due to the specificities of the market, strict regulation protects the real potential of the doctors who generate the turnover and are therefore the target group. Prescription medicines cannot be freely advertised in most countries, and pharmacy turnover data are only available at the sub-regional, district (brick) level, so neither the specific number of patients nor the number of prescriptions is available at the doctor level. Representatives of pharmaceutical companies, therefore, must estimate the potential of prescribing doctors indirectly. Sales representatives are responsible for getting to know the doctors practicing in their territory through regular visits, in the same way, that teachers get to know the skills and qualities of the students they are responsible for during classroom activities [19].

Targeting can be done on the basis of two main categories, and within each category, several criteria can be applied. These two main categories are potential and loyalty (or engagement), both of which can be identified and applied in secondary school talent management.

6.1. The potential

The concept of potential, in our case talent promise, is challenging to define, but the various talent models describe it well. In simple terms, we consider gifted those students who can perform at well above-average levels in an area of ability. In order to identify giftedness, we need measurements and an analysis of the measurement results. It is important to emphasize the plural, as many promising talents will block and underperform under the pressure of the all-important, unrepeatable assessment [20]. On the other hand, we do not have a test that will prove talent beyond all doubt. Similar to the pharmaceutical industry, approached from several angles, the aggregated results of different measures and approaches help to give a good estimate of the potential either of a given doctor or a given pupil. The next couple of assessments provides an extendable, customizable system to assist potential calculation.

One important area to measure is digital competencies. When measuring, it is important to use formative assessment, even monthly or biweekly frequencies. Many students experience testing as a stressful situation and underperform, especially in the case of summative assessment [20]. To reinforce the formative character, it is advisable to have students write playful tasks and tests of a quiz nature. Kahoot is a well-known and popular environment [21][22], and interesting and playful exercises can be found on the e-Hod (Bebras) [23] and CS-Unplugged websites [24]. In the tests, care should be taken to ensure that there are also simple tasks that all students can do so that they do not become demotivated by the potential failure. At the same time, more difficult tasks should be included in these tests, which require the outstanding ability to solve correctly. Such tasks can be found in the archives of the OKTV competitions [25] or on the websites of international competitions. The results of these tests can be quantified and summarized.

In addition to measuring competencies frequently, it may also be useful to measure other abilities occasionally. For example, completing a general intelligence test helps with talent selection. A high quotient on a general intelligence test is often an indication of outstanding ability or talent in several areas [6][7]. Of course, this does not automatically indicate IT talent, but it can be a useful component of potential. During digital culture lessons in a classroom equipped with computers, it is possible to have students complete an online intelligence test.

Talent models attribute an important role to creativity in addition to intelligence. Creativity is also difficult to measure, but there are some available online tests to assess it. On the other hand, programming problems are characterized by the existence of several good solutions. Thus, the better way of measuring creativity is to discuss the possible implementations of problems in digital culture lessons, and select pupils who have unique, creative ideas during this discussion.

The results of the creativity and intelligence measures can also be quantified so that these results can be added to the scores, and results of digital competence. While subject knowledge and competencies can be measured on a weekly basis, general intelligence and creativity are enough to measure once a year. Of course, these abilities also change over the course of secondary schooling, but for the purposes of measuring talent, these changes are generally not significant, with only small differences between the values measured at different points in time.

6.2 The engagement

The other dimension of targeting is based on loyalty and engagement. Loyalty means customer loyalty, which is a useful indicator in business, while engagement is more applicable instead of loyalty or loyal to IT at Secondary school. Even if a talent is recognized and identified, the student may not be interested in the subject and may not want to engage with it. A typical case is when a student has a talent in mathematics in addition to computer science and prefers to focus on mathematics. Many students learn English through the use of computers and computer games, and there may be some who still see IT as only a useful tool and commit themselves learn English. The students' environment can also influence their engagement, whether it is peer groups, parents, or another teacher who pushes the student in a different direction. Commitment can be reduced by the lack of confirmation and confidence or personality traits such as laziness. Thus, as well as the potential that promises talent, it is important to pay attention to the level of engagement, the extent of it, and the reasons for it. Similar to the system of potential tests the next assessments help to measure, to approximate the engagement and these also form a system.

The level of engagement is boosted by positive reinforcement, good results in competitions, and a supportive atmosphere. These influence and interact with student motivation. Maslow's pyramid of needs can be used to test this. For instance, students in families with many children, even if they have good financial resources, are more motivated by goods, while others are motivated by recognition, respect, and kudos.

Defining the extent of engagement is more difficult, as it is complicated to measure at all, and has qualitative rather than quantitative components. Most can be based on teacher observation, but there are known, well-defined qualitative characteristics that are measurable and their results can provide data on the degree of engagement or the difficulty of recognition.

In addition to the various skills, the study of interpersonal and social skills, in other words, soft skills, is becoming increasingly common. In secondary school, communication skills, the ability to cooperate, and to participate actively in teamwork are of particular importance. These interpersonal skills are both measurable and easy to observe in class. In contrast to ability, it is often the underachieving students who need attention as potential talent prospects in the case of interpersonal skills [26]. This is particularly the case for IT talents.

It is also worth asking students to complete a simpler test measuring general personality traits. One example is the DISC assessment developed by William Marston, which is widely used in both business and human resource management. This test, in addition to the extrovert or introvert, task or relationship-oriented personality type, also helps students to identify their motivation and the communication style they need [27]. Since these personality traits are largely established by the end of secondary school, it may be sufficient to have students complete this test once during their secondary school studies.

Formative assessment is not only useful for measuring and giving feedback on subject knowledge but also for other competencies needed to learn and apply a subject. A SWOT analysis, similar to the SWOT analysis used in business, can be carried out with secondary school students. It assesses the strengths and weaknesses of a particular student and those opportunities and threats, that come from the pupil's environment. Using a predefined set of criteria students should be asked to decide whether the area is a strength or weakness in terms of internal factors or an opportunity or threat in terms of external factors. For internal factors, the analysis examines competencies, including skills such as independent learning and the ability to manage time. External factors analyze the effects of the environment, like family, school, classmates, friends, etc. One of the benefits of these analyses is that they remind and inform students of the competencies they need and the environmental features that affect their lives and studies. Internal factors can be gradually improved as a result of the learning process. The external factors, although not influenced by students, they can prepare to counteract those by recognizing the risks. Such a guided SWOT analysis is also recommended to complete with students every six months [28].

The DISC personality test, for example, helps to identify the backgrounds of motivation of a person, which can be used to identify whether the student is really unengaged, unmotivated, or simply introverted and unable to express his or her interests. The external factors of the SWOT analysis also help to build a picture of the student's motivation and commitment based on what factors he or she assesses as opportunities and what as threats. For those who see extra-curricular activities and competitions as opportunities and computer and video games as threats, engagement can be assumed. Both assessments help to reveal if there is potential talent behind the observed underperformance. Using this information in conjunction with classroom observation, the engagement of individual students can be well defined.

As with potential, it would also be useful to quantify commitment, but the above criteria only allow for this to a limited extent. However, they provide sufficient data for a three-level assessment, like committed or positive, undefined or neutral, and dismissive or negative.

6.3. Classification

In the business world, the last step of targeting is the segmentation of customers. In many cases, the classification and categorization of customers are based on a single criterion, the potential. Customers with a high turnover are important, and those with a low turnover are less important or even irrelevant. It is important to note here a fundamental difference between business and education, in the latter case all students matter, and classification provides useful information for classroom differentiation. In the pharmaceutical industry, which is used as a model, the potential-based approach is also typical, but increasingly a two-level, two-criteria segmentation is being used, where commitment and loyalty are examined alongside potential. The two categories are two axes, two dimensions of a Cartesian coordinate system. The horizontal axis is used to denote potency and the vertical axis is used to denote loyalty, with only the first quarter of the coordinate system being used. Also, in the case of two-dimensional classification, the first step is to classify prescribing physicians, who thus generate traffic, on the basis of their potential.

In school usage, based on the calculation of the potential presented earlier, students achieve different overall scores after summing up the results of different tests and assessments. Recommended the usage of the relative values, the calculated percentage from their scores. For each group of students, there will be a minimum and a maximum value, and the scores of each student will be distributed between these values. In a similar way to the norm-oriented assessment often used in public education, some point boundaries between the minimum and maximum values should be assigned. The common practice in the business world is to define three or four segments by setting two or three cut-off points. To distinguish between them, the letters of the alphabet are used, so that students in a class can be grouped into A, B, and C, or A, B, C, and D. The number of categories also depends on the number and homogeneity of the groups of pupils. For small or homogeneous groups, three groups are sufficient, for larger or very inhomogeneous groups, four groups may be used.

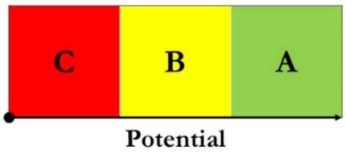

Figure 1: Segments by potential

Unlike the norm-oriented assessment, the point thresholds should not be set in relation to the average or other reference value but should take into account the number of groups. In the first group, the students with the highest scores, who are considered to have a strong promise of talent, are placed in this range, which, as described in Chapter 5, is about 20-25% of the students. This can be increased for small groups, can be selected by three students from a group of 10 students, or even four if there is a point identity. The middle range should be the widest, which includes about 50% of the students. The remaining students with lower scores are placed in the third group, in almost the same proportion as the first group, following the proportions known from the Gaussian distribution.

The second aspect, the inclusion of engagement in the segmentation, refines the potential-based classification. In business, a two-dimensional classification indicates more sophisticated planning and a more serious strategy. In a school context, it is almost essential to take into account the motivation and diligence of students. In business, too, the use of potential-based classification, often calculated on the basis of performance alone, narrows the target group and does not rely on the skills of the salespeople. This may bring the expected turnover in the short term, but in the long term, it can result in a competitive disadvantage. In public education, it also narrows the target group by excluding students who have the promise of talent, but it is required more and more sophisticated work to reveal it. Personality traits and interpersonal skills are difficult to quantify, as students are assessed according to a number of different criteria and carry qualitative rather than quantitative information. However, it is important to use them to compensate for the potential calculated by competency tests, where this is justified. This, of course, requires more attention and more professional knowledge and work on the part of the teacher.

Based on the 3-degree scale proposed for engagement, 3 well-defined groups emerge. Thus, when combined with the 3 groups formed by the potential, students can be classified into a total of 9 groups. The second dimension aims to make the boundaries of the existing 3 groups more flexible and more easily crossable. One of the main drivers of the learning process is motivation, which is an important part of engagement. A lower-scoring but motivated student can often be engaged in more challenging tasks than a higher-ability but less motivated student. It is for this reason that the two criteria classification places students with lower scores but motivated by the potential in the higher segment.

The introduction of a second dimension may of course change the boundaries defined on the basis of potential. The boundaries are flexible, so in such cases, it is advisable to modify the boundaries, so that the proportion of students in groups A, B, and C is as close as possible to the 25-50-25 percent distribution.

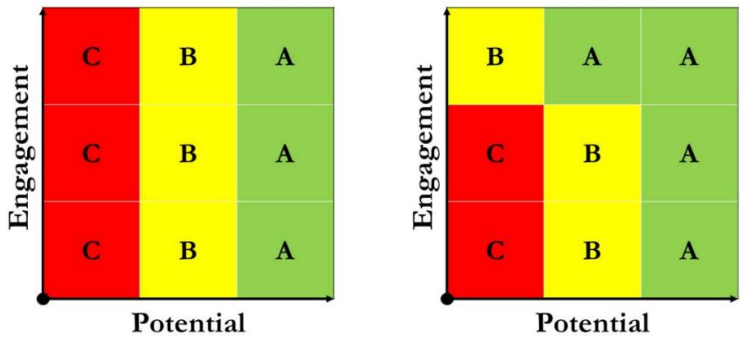

Figure 2: Two-dimensional segmentation and the corrected one

The assessments are continuous during the academic year, and the overall scores will change accordingly, with students in the third group can be moved to the first group and vice versa. Students placed in the middle group may move up or, in the absence of this, into the third group as a result of educational activity in the school and individual learning, interest, and motivation when the new classification is made.

The purpose of the classification, and the grouping into different segments, is to ensure that students receive the appropriate tasks and education in the classroom according to the measurements and the activity. On the one hand, this helps the teacher's work, provides a framework for differentiation in the classroom, and on the other hand, it is also useful for the students, because they can be given tasks that are challenging according to their abilities, and their interest, but not impossible, and provide the opportunity for a sense of achievement, which is essential for a successful learning process. While the commonly used classroom differentiation focuses on only the potential this kind of classification also takes into soft skills, and personal traits as well as the intent of further study.

6.4. Timing

In the business sector, companies operate sales cycles linked to calendar periods. Quarterly sales cycles are common, but there are also trimester, six-month, and annual cycles. Depending on the company's strategy, the current ratings need to be reviewed generally every sales cycle, but at least once a year. In public education, the half-yearly cycle is typical, so it is sufficient to review the classifications every six months and to reassess each group of pupils. The level of potential and engagement is constantly changing as the results of formative assessments or possible competitions are entered into the teacher's spreadsheet. Engagement may also change, this is typically less frequent. The scores over the course of the semester, together with any changes in attitude the teacher records. This information is tracked and monitored by most teachers anyway, so it does not represent an additional burden for the teacher. And the evaluation of the data collected is only an additional task every six months, which usually takes less than an hour using the method described above.

7. Pilot targeting at secondary school

The group of students selected for testing is a grade 11 computer science special class at a secondary school in Budapest with a total of 22 students. In the previous grades, they had been taught computer science by other teachers, so we started working together without any prior knowledge of the students.

After an introduction, in which their future goals were covered, the students completed a DISC test. This provided a baseline for the teacher to get to know the students' main traits and behavioral motivations [27].

The first test to assess the student's previous studies was a playful quiz in Kahoot, which did not require any specific programming knowledge. It is a diagnostic assessment, that helps determine the potential of students. At the beginning of the semester, there is no pressure on students to achieve a better grade, the quiz format motivates students to achieve a better ranking so that students experience the assessment as a game. Regular assessment in a quiz environment is perceived by students as a regular game, which they often experience as the highlight of the lesson. During the first two months of the semester, pupils completed tests on the following topics in a Kahoot environment:

- how computers work, Neumann principle
- algebraic operations and logical expressions
- using the numeral systems (focus on binary)
- search and sort algorithms

The first major contest was the Bebras competition, which we entered together in the second week of November. The results of the Kahoot test and Bebras competition are now sufficient to produce the first classification. First, a potential-based classification was made based on the aggregated scores of the competency tests.

However, the aggregate assessment should take into account possible bias factors. In particular, in the case of regular assessments, it cannot be guaranteed that all students attend all lessons, so any absence must be taken into account. Different scores are achievable on different tests, so the results are not so comparable, the sum may cause disproportionality. It is therefore advisable to use relative values, the average of the percentages achieved in each test, rather than the sum of scores. There may also be differences in the difficulty levels of tests, so the more difficult tests can be given greater weight. In the present study, the scores of the Bebras competition have been weighted twice and the tests that were not written have been excluded from the calculation in order not to unduly reduce the average of absent pupils.

The table includes the initials of the students, the results of the first diagnostic assessment, the additional Kahoot tests, and the results of the Bebras competition. The results of the 5 tests taken in 10 weeks already provide a good basis for measuring continuous performance, which is necessary to calculate the potential. With 22 students, the inclusion of 4-6 students in category A is justified according to the Pareto principle. In the results of the given tests, it is observed that there is a larger point difference between students 4 and 5 than between students 5 and 6. In the lower range of scores, there is a larger difference between 5th and 6th, but there is also a separation between 4th and 5th. A potential-based ranking can best thus be constructed in a 4 - 13 - 5 split, which can be further refined by including engagement.

Pupil	CT	AT	NS	SA	BS	Avg
HA	53%	100%	89%	87%	87%	84%
BD		85%		80%	82%	82%
ZA	63%	85%	0%	60%	98%	81%
KM			68%	93%	69%	80%
CM	58%	96%	79%		77%	77%
KD	48%	81%	58%	93%	93%	77%
VA	50%	100%	79%	67%	77%	75%
PM	48%	88%	95%	67%	71%	73%
GD	53%	96%	79%	67%	71%	73%
TB	50%	73%	79%	73%	71%	70%
GH	30%	96%	79%	73%	66%	68%
IB	58%	81%	84%	67%	55%	67%
PD	50%		68%	53%	81%	67%
LD	53%	69%	63%		74%	67%
CG	45%	92%	68%	73%	53%	64%
RA	65%		47%	87%	55%	62%
HR	55%	85%	68%	60%	50%	61%
DZ	48%	96%	53%	67%	47%	60%
BJ	40%	58%		67%	61%	57%
PS	45%	88%	74%	53%	31%	54%
PB	50%	73%		40%	49%	52%
MP	58%	62%	32%	40%	47%	47%

Table 1: Potential-based classification of pupils

The activity of students in class is good, despite the higher headcounts in this group, which is unusual for IT lessons. The monitoring and tracking of classroom work and student motivation is an important teacher task. So, it is also advisable to record the activity observed in each lesson with at least a small plus sign or a minus sign, or possibly a zero to indicate neutrality. This helps to ensure objectivity, which is very difficult to achieve in the case of such qualitative traits. In general, students with the highest scores on the scoresheet on which the potential-based grading is based are also spectacularly active in lessons. However, after two months, 7 students were still at 0 points because they had not shown any measurable classroom activity. Their better understanding and more objective assessment are important, and the results of the tests help with it.

According to the DISC personality test, half of the group members have introverted personalities, their motivations are not so visible, and expect to be spoken to and asked questions by the teacher. Those passive pupils, who are introverted by DISC assessment, got an extra point as a correction score in their loyalty. Extroverted pupils are proactive and often speak their minds without being prompted. Some of them were passive, sometimes a little hostile in class they got 0 points for their engagement. Those students, who like to study IT and who are successful in computer science, generally have S and C DISC traits. This is also observed in this given math and computer science special class group of students. There is only one student whose DISC test revealed neither the S nor the C trait to be dominant in their behavioral characteristics.

As part of the formative assessment, at the end of October, students completed a SWOT analysis of their own using the template prepared [28]. On one hand, it develops students' self-assessment skills and on the other hand, it gains a deeper understanding of the qualitative characteristics of engagement. Based on the external factors of the SWOT test, additional students were awarded an extra point, who felt that the competitions and the afternoon sessions offer a good opportunity for their development. This guided SWOT test sent important feedback to the teacher, pointing out that the skills of co-curricular work and cooperation are weak within the group, and pupils need organized group work in lessons.

Using the DISC and SWOT analysis, 3 of the 7 students with previously unassessed activity remained in the passive, unmotivated category. Three students got one point, so their engagement achieved a normal level, while one student got a correction factor based on both tests and was placed in the engaged student category. Finally, the potential-based classification can be refined by the engagement values. Starting point is the 3 ranges of potential calculated based on the point counts. As the collected table of engagement also contains three values, the two-dimensional classification can be illustrated with a 3x3 table. The first step is to extend the table to the second dimension independently of engagement values, and then the highly engaged students in the top row of the table are moved up one category on the previously developed potential scale, where reasoned. Finally, using the two-dimensional segmentation, the classification shown in Table 2 was obtained after the corrections were made. Four students were placed in a higher category based on their engagement, three of them in the A segment. Based on their test results they were not potential IT talents however, they got more attention, a better chance via this segmentation.

After the modification, if the bounds for the potential are left unchanged, the distribution of pupils is 7 - 12 - 3, which is disproportionate and far from our theoretical rate. The important aim of teaching is to support and develop pupils, so this deviation is useful from a didactic point of view. However, at the bottom of the table, easier tasks may motivate weaker students more, so the boundary of category B was upper a little. It improved the ratio of distribution, the number of pupils is 7 - 11 - 4 by segment.

Analyzing the table, we observe an interesting and challenging student for teachers, identified by the initials KM. The student scores well on various tests, but his engagement is missing, and his class work, or lack of it, is not explained by the personality tests he has taken. In his case, a personal interview was required to discuss his future and interests, so that he can be involved in more active class work with appropriate tasks and to develop his good IT skills. He explained that he would like to study movie directing which is far from IT in his point of view, in the first discussion. This was followed by further discussions on a weekly basis. We analyzed together movies from an IT aspect, which highlighted a lot of misunderstandings. The breakthrough was achieved by a personal story about a former pupil, who disliked IT, but he learned it. Especially multi-media applications as he was interested in those. After secondary school, he couldn't find his place, he was not admitted to the university. He tried to get an assistant position on movie projects when a director asked him, if could he handle the Final Cut application. It was his entry into the world of movies, and his greatest success was his participation in the Oscar Gala where a film won the award in the short film category that was cut by him [29]. It has changed his motivation and his engagement. His customized tasks mostly refer to movies and the process of movie-factory to stay his interest.

Pupil	CT	AT	NS	SA	BS	Avg	Engagement
HA	53%	100%	89%	87%	87%	84%	2
BD		85%		80%	82%	82%	1
ZA	63%	85%	0%	60%	98%	81%	2
KM			68%	93%	69%	80%	0
CM	58%	96%	79%		77%	77%	2 ▲
KD	48%	81%	58%	93%	93%	77%	1
VA	50%	100%	79%	67%	77%	75%	2 ▲
PM	48%	88%	95%	67%	71%	73%	2 ▲
GD	53%	96%	79%	67%	71%	73%	1
TB	50%	73%	79%	73%	71%	70%	1
GH	30%	96%	79%	73%	66%	68%	
IB	58%	81%	84%	67%	55%	67%	1
PD	50%		68%	53%	81%	67%	1
LD	53%	69%	63%		74%	67%	0
CG	45%	92%	68%	73%	53%	64%	1
RA	65%		47%	87%	55%	62%	1
HR	55%	85%	68%	60%	50%	61%	1
DZ	48%	96%	53%	67%	47%	60%	1
BJ	40%	58%		67%	61%	57%	1
PS	45%	88%	74%	53%	31%	54%	1
PB	50%	73%		40%	49%	52%	2 ▲
MP	58%	62%	32%	40%	47%	47%	1

Table 2: Two-dimensional classification of pupils

This kind of teacher activity is also well-known activity of talent management it is called mentoring [30]. The best case is school provides a full-time mentor for mentoring gifted students. Unfortunately, most school has not the possibility to employ a full-time mentor, so the mentoring depends on teachers' engagement. However, engaged teachers can get professional support from national talent organizations.

To summarize, the task assignment in 3 categories changed the classroom work. The activity was increased in each group. In addition to individual tasks 2-3 members groups were organized to practice group work and cooperation. The results of the formative Kahoot test are also improved week by week. Pupils are motivated by their customized tasks, that are suitable for their abilities. The motivated learning environment provides continuous development and gains for pupils.

8. Conclusion

Targeting and target group segmentation is primarily complementary tool to support educational activity, classroom differentiation, and talent management. It is not a fully personalized method, but it helps teachers to provide more customized tasks and activities for pupils based on their abilities. Continuous assessment as a regular formative assessment gives not only students but also teachers very useful feedback on students' progress, and about topics that are difficult to learn and understand. For A students, it is advisable to use the acceleration and enrichment method, which is also used in the IT and digital culture subjects and is widespread in gifted education [31].

The three groups of pupils are still manageable as a classroom differentiation, meanwhile it provides customized tasks for each group. The segmentation creates competition between pupils. The teacher must observe if this blocks a student, it should be managed with personal mentoring. Generally, segmentation and targeting have more benefits than disadvantages. While the difficult tasks demotivate weaker pupils, while the too-easy tasks are boring for gifted students. Segmentation-based differentiation provides a usable solution as it evaluated whole pupils instead of only their results. The weaker pupils get suitable tasks as well as the gifted, so the more active classroom work provides development for each pupil and helps to gain engagement for IT. The wider classroom work gives a possibility to recognize more talented students in IT. Engagement in IT does not mean that every pupil must study IT at university. IT covers every area of life and science, so the pupils can use their well-developed IT knowledge everywhere. The high-level IT knowledge from secondary school provides a competitive edge for pupils in most areas of life [4].

Talent development and identification also require practice, solving problems of varying difficulty, both individually and in groups, for example in project work. It is important, however, that students experience success in solving their tasks, which require differentiated classroom work with tailor-made or at least group-customized tasks. This is supported by this presented targeting and grading adapted from the business world. The proving requires wider research on bigger samples.

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