GIFTED CHILDREN IN THE SIGN OF SUCCESSFUL TECHNOLOGY TRANSFER

Šárka Portešová, Michal Jabůrek, and Ondřej Straka are psychologists working at the Faculty of Social Studies of Masaryk University, where they deal with developmental psychology, psychological assessment, and primarily, the psychology of gifted children. Together with a broader team of colleagues, they have developed a unique diagnostic system called Invenio, which is the topic of this interview.

You are psychologists whose main professional domain is assessing and educating gifted children. What are the characteristics of these children, and why do you think it is necessary to foster their talents systematically?

ŠP: Traditionally, we refer to children as gifted if they excel in a particular area above their peers - their abilities are, therefore, significantly advanced. This may be a single, narrowly defined ability, but some gifted children are more versatile, so their talents are expressed in more than one way. How advanced a particular ability is at the current age naturally varies from child to child. In extreme cases, a child's abilities and/or knowledge may be comparable to or greater than those of a typical adult. At the outset, we must also emphasize that as psychologists and authors of the Invenio tests, we focus specifically on intellectual giftedness, and we are therefore concerned with finding and supporting children with exceptionally advanced intellectual abilities. Of course, this is not the only type of talent – some children are gifted in the field of arts (such as music, painting...), sports, or in other specific areas. These types of giftedness are also important and often very fascinating, but they are at the same time the main domain of other disciplines, and as psychologists, we come into contact with them rather incidentally.

When talking about children with intellectual gifts, in the first place, they are characterized – practically by definition – by their exceptionally developed intellectual abilities. Logical thinking probably comes to mind first and foremost, but the range of abilities in which some children may excel is broader and may include, for example, spatial imagination or linguistic talent. Less obvious may be another fact that has, however, been confirmed by ample psychological research in recent decades. It is that exceptional intellectual talent is often accompanied by typical motivational, personality or emotional-social characteristics in which these children differ from their peers. Briefly, we can mention curiosity and a heightened need for knowledge, perfectionism, or a preference for the company of older children or adults, to give just a few examples. Conversely, these children often do not enjoy games or other leisure activities typically enjoyed by peers of their age. Often, gifted children are also characterized by developmental asynchrony – a condition in which individual mental abilities develop unevenly. Thus, the same child may have an adult level of logical thinking or mathematical knowledge but be very immature emotionally, even compared to peers.

Authors of the Invenio system: Šárka Portešová (top), Michal Jabůrek (middle) and Ondřej Straka (bottom). Source: Invenio

OS: From this also follows why our educational system must pay systematic attention to gifted children. The matter has two levels: individual and societal. In the first place, of course, it is necessary to mention the educational needs from the point of view of gifted children themselves. As they have advanced thinking and usually also advanced knowledge, they may find much of the curriculum in particular school subjects uninteresting and unstimulating. Imagine a typical third- or fourth-grader being forced to relearn the first grade curriculum - recognizing individual letters, learning the seasons of the year, counting to twenty... The absurdity of such a situation is quite obvious, and it is equally obvious that the child would probably not enjoy such teaching very much, nor would it be very beneficial to him or her. Less apparent is the fact that children whose cognitive development is accelerated by, say, 2-3 years of age can go through a very similar experience if they receive standard instruction in their current grade without any adjustment or consideration of their giftedness. Yet, the solution may not always be to simply skip a grade, precisely because of the developmental asynchrony mentioned above. For example, a child might thrive academically in a higher grade but might also have great difficulty fitting in with new classmates. Fortunately, there are appropriate pedagogical approaches to take account of a child's giftedness in his or her current environment, such as curriculum enrichment, curriculum compacting, mentoring, and others. Such forms of education are not only beneficial for the gifted children themselves, who will usually be more motivated and happier at school, but are also beneficial on a second, societal level. Talents are the most valuable resource our society has, and any support given to their development can return many times in the future. However, to support these children, it is necessary to find them first, and this is probably the biggest obstacle to optimal care for the gifted in our country in the long term.

MJ: In Czechia, the system of pedagogical-psychological counselling centers is responsible for identifying gifted children and recommending adjustments to their education. However, these institutions also deal with several other problems (learning disabilities, behavioral disorders, emotional difficulties, and many others), which leads to long waiting times and the fact that when a potentially gifted child is diagnosed, there is often less time than would be optimal for the whole assessment. An even bigger problem is that only a certain group of parents – especially those who are motivated and those who have already noticed the manifestations of exceptional giftedness in their child – usually request an examination at the pedagogical-psychological counselling center. The second source of applications for examination at the counseling center are the nominations of pupils by the schools, or more precisely, teachers. However, as several studies have shown, pedagogical nominations are only partially reliable and depend heavily on the experience of the teacher (experience does not only refer to the mere length of teaching practice, but also whether or not the teacher has already met a gifted pupil during that time). Thus, a large number of gifted children are not examined at all in the PPCS, and their educational needs are not taken into account in school. This is also evidenced by statistics from the Czech School Inspectorate, according to which the number of „formally" diagnosed children is lower than theoretical assumptions by an order of magnitude. This situation has been going on for a long time and, unfortunately, does not seem to get any better. This was the main incentive for us to develop the Invenio diagnostic system.

What does the Invenio system look like and what may it be used for?

ŠP: Invenio is a screening diagnostic system that enables large-scale testing of specific cognitive abilities in children. The system uses the principle of game-based assessment, where individual tests are framed as computer games from the child's perspective to increase motivation and reduce potential test anxiety. At the same time, however, each of these games functions as a full-fledged psychological test in the background, with established basic psychometric parameters that are comparable in their values to those

of standard tests commonly used in individual psychological practice. The game tests are administered to children online, through a common web browser, typically in the computer lab of their school. The system, therefore requires no installation or complicated maintenance by the school.

MJ: Because of our academic background, we try hard to have the diagnostic games stand on firm theoretical footing. The content of the tests is therefore based on the so-called CHC theory of intelligence, which is the modern and probably most influential model of human cognitive abilities at present. The advantage is that several widely used psychological tests for individual diagnostics are also based on this theory, so if a child is tested by a psychologist and at the same time by one of the Invenio games, it is in principle possible to integrate information from both sources, allowing a deeper and more accurate understanding of the child's abilities. Abilities that can be measured by Invenio game tests include, for example, various types of logical thinking (inductive, deductive, quantitative), learning efficiency, spatial imagination, information processing speed or working memory. The Invenio system is primarily designed to find gifted pupils, but it can reliably measure individual abilities in the average and below average range, and for all children the system generates a report for parents after testing that includes the results and recommendations for the child's further development.

What are the main advantages of the Invenio system as compared to classic psychological tests? Does it also have some drawbacks?

OS: Traditional intelligence tests can be boring or stressful for many children. This is especially true of tests that can be administered in groups, and this problem is all the more serious the younger tested children are. For this reason, there are relatively few classic group-administered tests on the market suitable for the primary school children, and they are completely lacking for the youngest pupils. Invenio tests are designed to increase children's motivation and reduce potential test anxiety through game-based principles. It both makes the testing process more enjoyable for children, and it also leads to better quality of results, because if test-takers are, for instance, stressed, their scores are likely to be lower than

A screenshot of a game testing associative memory. Source: Invenio

their actual abilities. Owing to these benefits, it is possible to administer Invenio truly across the board, to all pupils in a classroom. The computerized form of administration has yet another advantage over pencil-and-paper tests: it allows recording and further analyses of data other than simple correctness/incorrectness of answers to individual items – for example time taken to solve individual items, indicators of different solving strategies, etc.

MJ: Currently, the main disadvantage of the Invenio system is, in our opinion, that it does not yet cover the entire school age period. Most of the tests are now designed and standardized only for primary school children, in some cases with little overlap into the lower grades of the secondary education (e.g. grade 6 or grades 6 and 7). We would certainly like to change this in the future. Another disadvantage lies in the screening and group-based fashion of testing itself, which can be negatively affected by, for instance, the classroom setting, distractions from classmates, and so on. At the same time, unlike individual assessment, it is not possible to observe each child during testing, so a valuable source of information is missing. Screening tests can therefore never completely replace individual assessment, but to our mind the two methods can complement each other very well.

You thus represent one of the handful of innovations in the area of applied social research, which – as a matter of fact – is focused on society as a whole. Why is, according to your opinion, this kind of applied results in social sciences so rare? What needs to be changed?

ŠP: Yes, we strive to ensure that our outputs have a real impact on society and are meaningfully applicable in practice. There are several reasons why there are relatively few social science innovations of this kind. There is often a lack of sufficient support for applied research in this area – unlike engineering or science, where applications are more obvious and easier to fund. Another factor is the complexity of translating social science knowledge into practice: the results are often complex, requiring long-term testing and implementation in specific social contexts.

Furthermore, during the several years of development of our diagnostic system, we have repeatedly encountered the fact that university funding still primarily values basic research outputs, especially publications. Applied research, while it may have direct and significant economic and societal benefits, is not adequately recognized by this system. Therefore, I reckon that the research funding and evaluation system should be changed to reflect the real impact of applied projects. This would not only encourage innovation, but would also bring long-term benefits to the society as a whole.

Do you remember the beginning of the development? What did your first game look like?

OS: In our first game we used the principle of balancing the scales, described by Jean Piaget and known in developmental psychology for several decades. We have transferred the task, which may seem a bit tedious in its original form, to an underwater environment and incorporated it into a story in which a child has to help a biology professor named Triton to protect marine animals. The child is tasked with arranging groups of fish and other sea creatures so that they are equally strong and share fairly the food provided. We used this game to give a tryout to the demands of overall game development, which similarly manifested themselves in all further gamified tests. The principle of the test problems must first be piloted in an „off-line“ form with real children; if we find that they do not understand it, or that it is not very attractive to them, it must be modified or changed completely. At the same time, we have verified how important the work of programmers is, as well as that of graphic designer – for example, the current

graphic representation of the game was only achieved on the third attempt. We also set up procedures for standardizing and conducting psychometric analyses on the Triton game. All of this required a huge amount of work, but it paid off; the game has been in live use for over 5 years and is still in high demand.

How is the system employed as of now?

MJ: We currently offer the system exclusively to schools through the so-called Shopping Center of Masaryk University. When a school expresses interest in using Invenio, we arrange the composition of the games and the grades involved, and then provide the school with all the necessary information and illustrative instructions in the form of simple videos. Included in the materials pack is a template letter that the school can customize and send out to parents. In the letter, parents will find information about testing, the benefits of getting involved and a link to register for Invenio. On the registration page they enter basic information about themselves, their child and provide consent for testing and the storage of personal data. As you can see, it´s all done electronically, so the school is not burdened with the hassle of collecting paper consents. We then fix a testing date with the school, send them a document with a list of registered pupils, a link to access the games and a picture code for pupils in the class to log in. A member of the staff will then seat the pupils at their computers or tablets, help them log in if necessary, and that´s pretty much it. The children hear all the instructions in their headphones and play the game independently. After the testing, the system will automatically generate the reports for parents with the results of their child's testing, which is accessible through a profile they created during the registration. We will also produce a report for the school within a few days.

As to paying for testing, there are several ways. Some schools use project money, grants from foundations supporting education, others try to arrange with the region or municipal administration to provide large-scale testing involving more schools. Leaving the payment to the parents is also an option. In this case, however, only those who pay for the testing are tested. But this again runs the risk that only pupils with motivated parents will be involved and that the potential of pupils whose parents are not interested in testing will be overlooked. Therefore, if at all possible, we recommend seeking project funding.

What happens when the testing gets finished? What kind of outputs the system provides and who can further work with them?

OS: On creating the testing model, we have been very much concerned with the issue of providing information and of data protection. There are two principles here that unfortunately go against each other. On the one hand, it is desirable for a school to get as much information as possible about its students and to be able to use it for further pedagogical work with them. On the other hand, data on intellectual abilities are quite delicate. For example, it is understandable that parents may be concerned about providing results to the school if the child's results are average or below average. For this reason, the system is set up so that only parents have primary access to the reports generated by the system. At the same time, however, parents give their consent before the actual testing that, if the child comes out as gifted, this information will be passed automatically to the school. This gives the school the opportunity to start working systematically with identified gifted students shortly after testing and to provide them with an individualized educational approach that reflects their needs. The school will not automatically know about the results of other children unless their parents themselves voluntarily provide the school with the test report. At the same time, in addition to the information on giftedness, the school receives a global report summarizing the results for the class as a whole (without indicating results that could be linked to specific students).

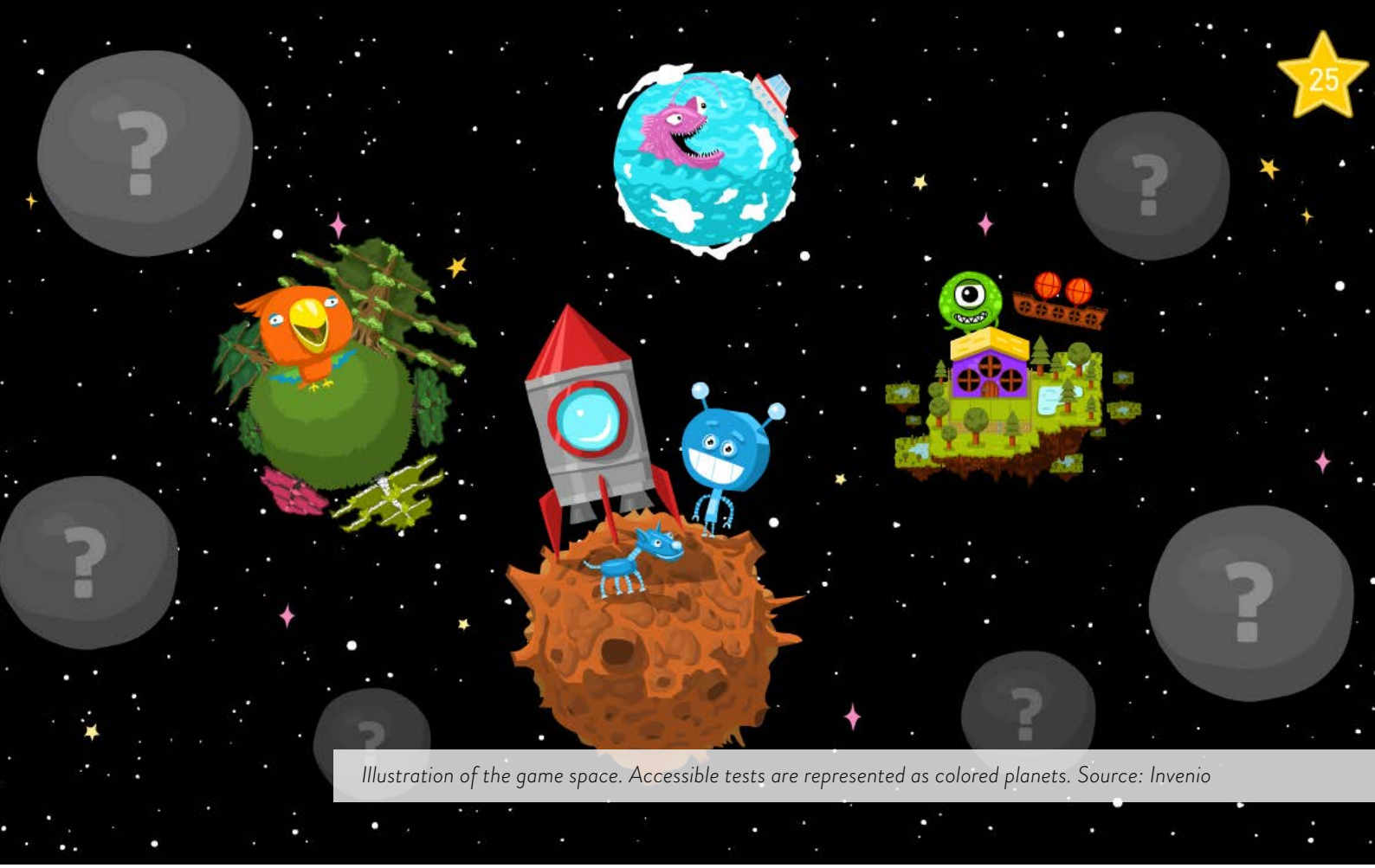
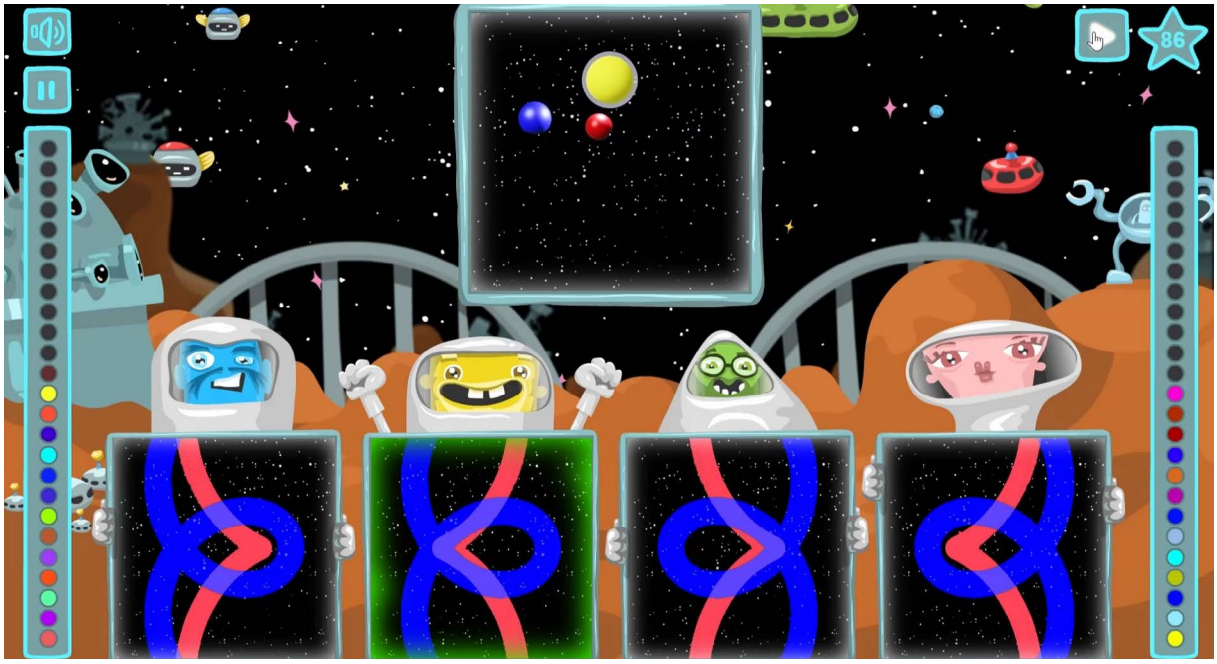


Illustration of the game space. Accessible tests are represented as colored planets. Source: Invenio

Regarding the outputs that are provided to parents, the system generates two types of reports simultaneously. The so-called Report for Parents is written in a more understandable, lay language, and its purpose is to describe in an accessible way which skills were measured during the testing, what results the child has achieved and what recommendations are made for his/her further development. A so-called Expert Report is also generated for parents. This is primarily intended for situations where the parent will seek further professional help for the child, i.e., visit a psychologist, educational specialist, or other professional, whether on account of giftedness or for other reasons. The expert report describes the basic psychometric parameters of the tests used and the child's results in the form of weighted scores, including appropriate confidence intervals. It, therefore, enables professionals to consider the results of Invenio testing in their own diagnostic and counselling work.

Is the Invenio system known to a broader public? Do you receive some feedback?

OS: In 2020, when we completed the test kit, which could be deployed in live operation, we had the opportunity to offer it to all fourth and fifth graders in South Moravia as part of a project funded by the South Moravian Region. In this first phase, many schools did not know what to expect from the testing. Although the testing was free for schools, thanks to the regional funding, it was necessary to approach them actively, explain the benefits of testing, and sometimes almost persuade them to participate. It is gratifying that the feedback from schools was overwhelmingly positive, and after the project had ended, many schools began to actively seek ways to continue testing in the future years, often with parental involvement. As awareness of the Invenio system has gradually spread, more and more individual schools, as well as representatives of local administrations such as municipalities, regional institutions, and local action groups, have approached us with an interest in testing. The Invenio system and the topic of gifted children in general are also becoming attractive to the media, and consequently, in the last two years, individual members of our team gave numerous interviews to the press, as well as to radio and television.



Picture showing a game designed to test spatial abilities. Source: Invenio

ŠP: Positive feedback from the professional community also helps to raise awareness. Recently, our team has received several awards for the Invenio system, which we greatly appreciate. In 2023, a project in which 4 tests of the Invenio system were developed won the TAČR award for the best project in the Society category and was also the overall winner of the year's „Czech Idea" award. In 2024, the Invenio team took 3rd place in the competition organized on the occasion of Transfera Technology Day, focused on projects implementing technology transfer. We are also very pleased with the interest and appreciation from our parent university, which was expressed in the form of the MUNI Innovation Award, bestowed in 2023.

Could you describe in more detail the process of technology transfer – how it is/was carried out in the case of your assessment system?

ŠP: Most of the tests that are part of the Invenio system were developed through the projects supported by the Technology Agency of the Czech Republic (TAČR). This is important from the point of view of technology transfer, because this provider does not put any obstacles to commercializing the outputs of projects funded by it; on the contrary, it supports and appreciates it. From the creation of the first tests to the present day, their distribution has been carried out through Masaryk University, or more specifically, the Faculty of Social Studies, where we work and where the development of the tests was realized. Although this method of distribution is possible, over time, we started to encounter more and more problems, usually of an organizational or bureaucratic nature. The fact that the faculty is not primarily dedicated to business, nor does it have much experience in this field, makes some processes unnecessarily complicated and, consequently, costly. As one example for all, we can mention the necessity to interrupt the distribution of tests always at the beginning of December due to the closing of the accounts for the year. This is a time when schools, as our potential customers, often need to spend surplus money in the budget and we lose these contracts unnecessarily. It is also very problematic to use current profits from testing for longer-term investment in the system development. For these reasons,

we recently decided to create a spin-off and to carry out part of the operation and further development of the system there.

Did you come across any peculiarities resulting from the fact that this transfer of technology took place in the context of social sciences?

MJ: There are, of course, some specifics. One thing we have already mentioned is that because there are so few applied social science outputs, no one has much experience in using them. We have therefore often had to be the first to ‚blaze the trail'. Another specificity is tension between commercial potential and social responsibility. From a purely business point of view, it might be an effective strategy to set testing prices several times higher than they are now and to target only a rather narrow segment of parents for whom such a price would be acceptable. But that would go completely against the point of the large-scale talent searches for which we developed the system. It is a great matter of concern to us that children from, for instance, socially disadvantaged backgrounds should not be excluded from gifted support, as would inevitably happen if testing was on a purely commercial basis. We try to address this discrepancy in various ways - e.g. sponsorship, seeking support from local authorities, etc.

OS: However, we have one advantage over many science and technology applications in that we are not too constrained by the physical distribution of the product, and most importantly, we do not have to deal with patent protection. The fact that the Invenio system is primarily a software tool makes the protection provided by copyright law sufficient.

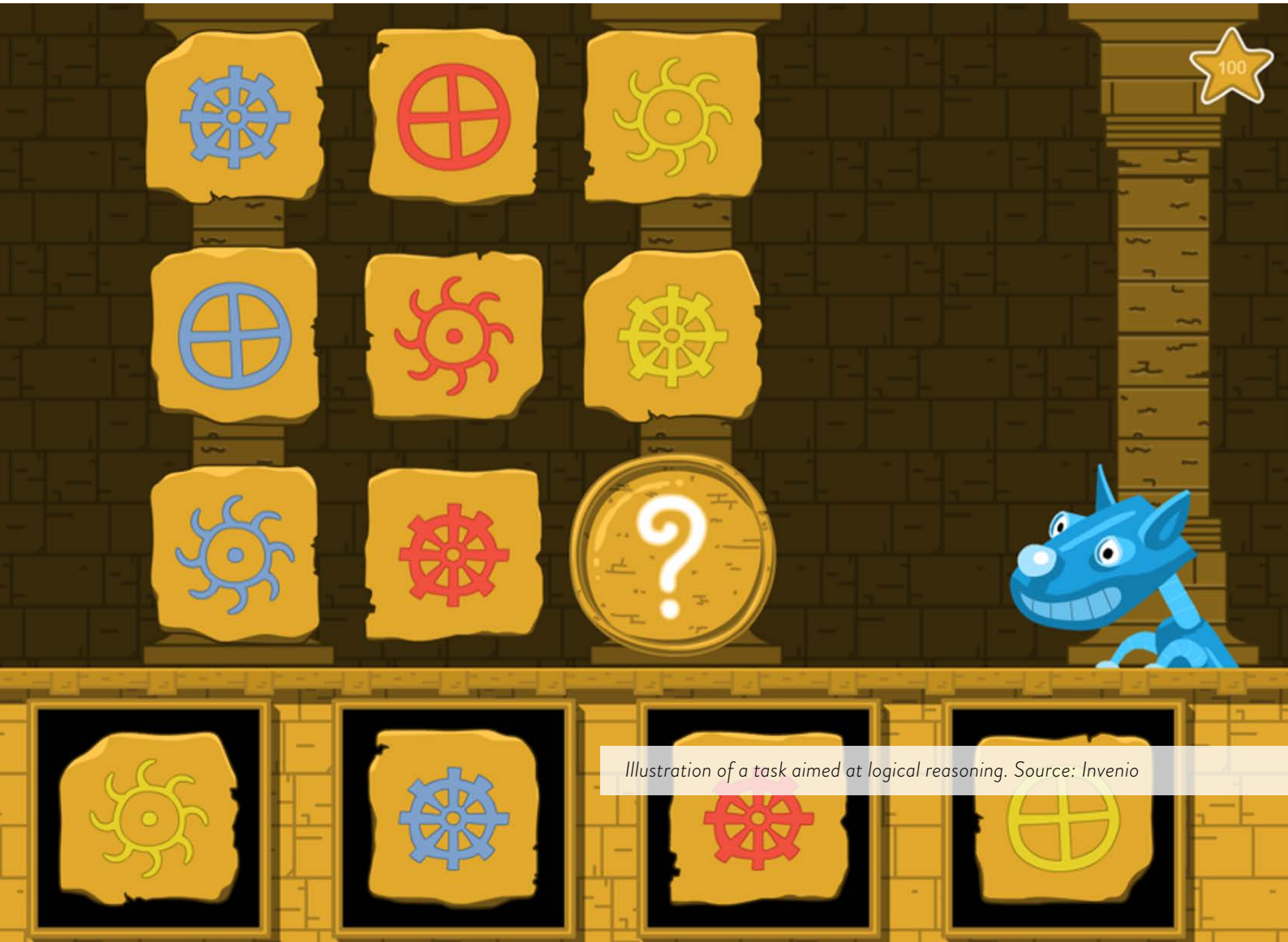


Illustration of a task aimed at logical reasoning. Source: Invenio

What are your next visions towards commercialization? What are your plans for the future?

MJ: As it has already been mentioned, we are currently setting up a spin-off that should partially take over the distribution of tests and further development of the system. For the next 1-2 years, we are planning some major changes. First, we want to expand the distribution models. In addition to the current method where group testing is requested by individual schools, we plan to create a module for home testing. Parents will be able to order a set of tests for their child directly, and the child will then complete the set of games (tests) at home. We are also planning a package of tests, designed primarily for school and counseling psychologists, which will be suitable for individual or small-group administration in addition to standard group testing. Second, we want to expand the age range for which we can offer testing. This will require the adaptation or development of tests designed for children in lower secondary education and possibly also for high school students. Third, we plan to translate some tests and adapt them for foreign countries – we are considering Slovakia as a first step, but we would like to expand to other countries after that.

Do you envision your future also in collaboration with the private sector?

ŠP: By setting up a spin-off company, we will enter the private sector a little bit ourselves... As far as the users of the Invenio system are concerned, the main part of our activities in the future will continue to be in cooperation with schools or their founders, i.e., with public entities in general. At the same time, we believe that our know-how in the field of computer-based cognitive testing is potentially useful for the development of applications intended, for instance, for the recruitment of appropriate employees, for personnel consultancy, and similar purposes. This kind of application would probably be of interest mainly for private companies. In the near term, however, we will not have the space to create this type of application; it is rather an open possibility that may be realized sometime in the future. In any case, such an activity would only be complementary to our main mission, which is to contribute to the development of gifted children.

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