The Hungarian who taught mathematics to tribal Papuans

Original article in Hungarian by Anna Mécs http://index.hu/tudomany/2014/03/28/dienes_zoltan/
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Zoltán Dienes, who inspired the thinking of children throughout the world with his mathematical games, passed away this January at the age of 97. A mathematics teacher, sometimes also called a magician, he wanted to protect students from the misery that was in wait for them in classrooms, and to build a new foundation for mathematics education. He believed that real knowledge is the ability to apprehend problems arising from our environment. Americans, who had a hard time recovering from the shock of the Sputnik crisis were open to new methods and thus Dienes's approach became popular in the USA in the early 1960s. His tools based on exploration and discovery were developed to represent mathematical structures, and enabled students and teachers to become equal, creative partners. Despite the early enthusiasm, Dienes is rarely mentioned nowadays.

The place is an upcoming city in New Guinea. Dienes was just beginning his educational experiment in a small cottage-like school on the edge of a city. He took out the pieces of one of his games, and told the students to do whatever they wanted with it. There was a long, mesmerized silence in the room. The kids didn't move. But then, with one playful task after another, their curiosity sparked, and soon the room was filled with the noise of passionate debate.

Tribal Papuans in war paint

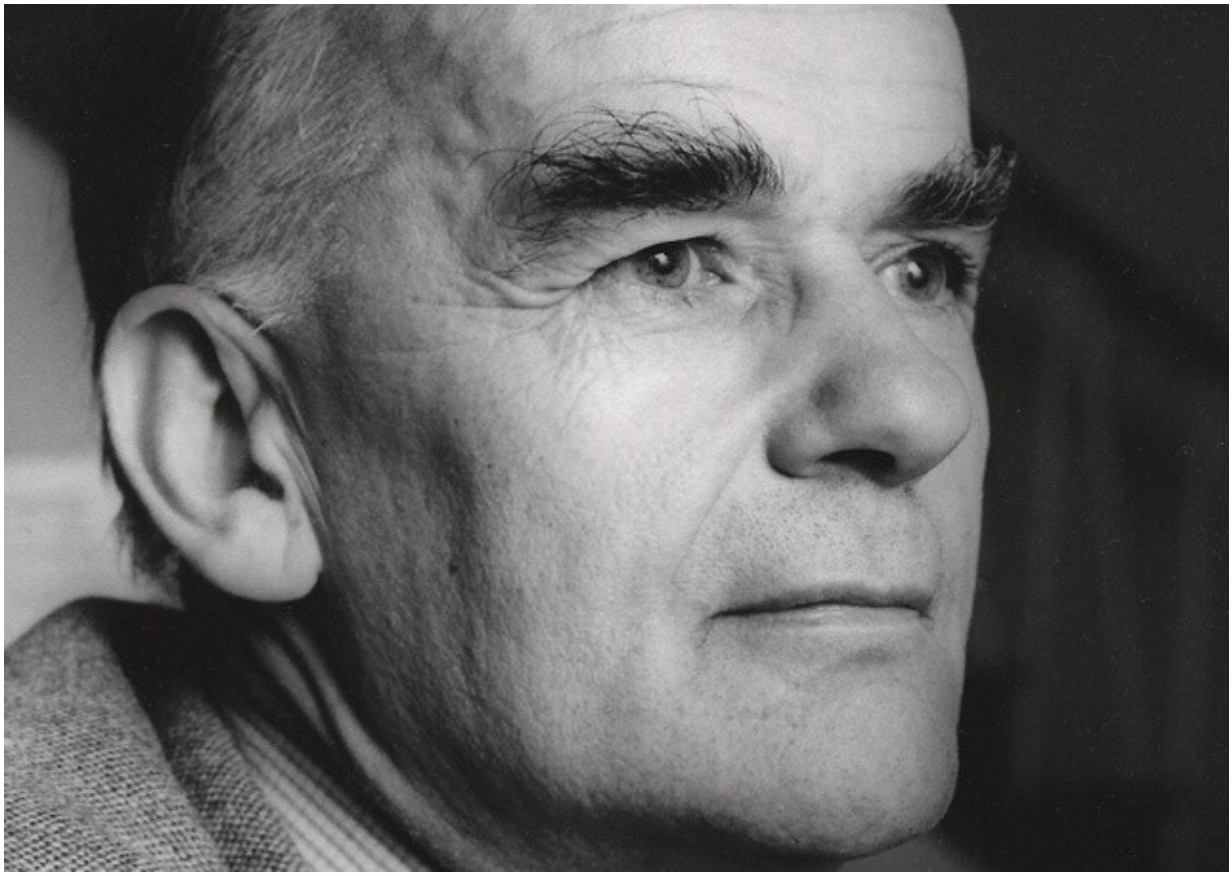
The supervisors of the school unanimously believed that the school should be a place for much more useful activities. They couldn't recognize either the early stages of logical

thinking, or the subtle signs of discovering mathematical principles – says Dienes in his autobiography. Therefore, he wanted to find a school without supervisors. The next day a native driver took him to a place where the river met the ocean, and told him that from that point on, the professor would have to continue on foot. To Dienes's inquiry whether the driver would help carrying the luggage, the answer was an unequivocal no. The crocodiles – he explained simply. So Dienes crossed the perilous river to get to a school two miles away from the ocean. Lack of supervisors guaranteed.

This is how one of his experiments of mathematics education began, and it continued for two years. He had a very special talent to immediately find a common language with children in all corners of the world.

Early years

His father, Pál Dienes was a teacher and a mathematician who took part in the first and short-lived communist government of Hungary in 1919, and therefore he had to flee the country after the collapse of the political system. They even had to sell their private library in order to pay the captain to smuggle him out nailed into a wine barrel! His mother, Valéria Dienes, was the first female professor in the country, having studied mathematics, music and philosophy. In 1920 she also left Hungary together with Zoltán and his brother Gedeon. For some time they lived in a Montessori children's home in Austria, later in a commune in Nizza. As a result, they learned to speak both German and French.



Gedeon – who later became a linguist and a dance historian – and Zoltán dreamed up all kinds of games and languages together. They developed a touch-based alphabet, in which the place and type of a touch together specified a certain letter. When they were around ten years old, they created their own language named “sazla” with very simple grammar. They also composed a dictionary with the most commonly used words. Another project was a fictional geography with several countries with detailed maps including roads, railways and schedules with real-time travels, which usually took place while they were at school. Their imaginary countries often almost ended up in military conflicts with each other.

In the summer holidays Pál took the boys to journeys across the world. “We changed our world-view about twice a year.” – Zoltán remembers, since his father was a Marxist and his mother a Catholic. They spent a few summers in Italy, where they learned Italian. Mathematics in school was mostly boring for him; he preferred solving differential equations under the desk. Fortunately his teacher did not punish him for his lack of attention, rather he decided to facilitate him through private discussions. At age fifteen he moved to the United Kingdom to live with his father. Here he found mathematics lessons – which contained almost no problem solving, just raw arithmetic – rather strange. Instead of solving problems, they merely applied theorems. He soon realized that he understood math better than the teacher, so he decided to stay silent during lessons in order not to embarrass him.

Let’s be constructive

In England he earned a degree in mathematics with average results – hiking and dating proved to be more exciting than the curriculum. He wrote his doctoral dissertation on the foundations of mathematics. Following that, he took a couple of teaching positions, but he couldn’t see himself in a primary or secondary school in the long term, so he started applying for university positions. He worked at a number of different British universities, feeling much more at home in this environment, teaching and carrying out his own research at the same time. He had a number of achievements mainly in the field of set theory before he moved to Leicester, where he would spend the next thirteen years of his life.

In his lectures he used a structural approach to mathematics: he would tell his students to forget everything they had learned before, so they could rebuild mathematics together. It was his belief, that looking at mathematics from a mathematical perspective is fundamentally different from just memorising complex problem solving strategies. But this message did not spark much enthusiasm then. Only years later, when his audience changed to elementary school students, did he manage to truly inspire.

Around this time he began to be concerned about the amount of impact he could have as a researcher. More and more he began to feel that he could contribute much more by changing mathematics education. It became increasingly clear to him that the subject was taught in a wrong way: that what he saw as beautiful and exciting was commonly regarded as scary and boring. He began connecting his research to learning processes: he thought there had to be a connection between ideas about the foundations of mathematics and learning the subject. Many look at mathematics as a closed science based on axioms carved into stone. On the other hand, people like Émile Borel, one of the mathematicians Dienes considered to be a role model, saw mathematics much more as a constructive and thus open discipline. This is how he came to recognize that the personality of children and their

mathematical conceptualization may be more closely related. He found proof of this in his experiments at the University of London, where he studied psychology. He came to the conclusion that constructive thinking is much more characteristic of children than analytical thinking, and that children of age ten were much more capable in certain types of mathematical problem solving than it was believed at the time.

According to Piaget, who was one of the best known researchers of cognitive abilities, children's capabilities are determined primarily by the stage of their development, which in turn is determined by their age. “Dienes believed it all depends on the kind of task and the way it is presented to the child. If we present tasks that are based on mathematical structures in a playful manner, then they are able to show surprisingly high cognitive achievements at surprisingly young ages.” – explains Sándor Klein, a mathematician and psychologist who used to work together with Dienes in the 70’s.

Dienes began working on a methodology that could create constructive opportunities during mathematics lessons. One of his areas of interest was positional notations (place value). He believed that the reason children did not have a deep understanding of positional notations was because the concept of exponentiation had never been introduced to them properly. This is why he created the tool called the multi-base arithmetic blocks which are a hands-on demonstration of different numeral systems and exponentiation. He created tools for several other mathematical areas as well from geometry to set theory. With all of these he made specific abstract mathematical principles visible, touchable and – most importantly – playable.

In the school where he began his experiments he was so successful that the children in the control classes also wanted to play his games. And so the experiment spread first from class to class, then from school to school. They began producing the tools in great volumes, and Dienes started holding seminars for teachers. After one of the sessions, a teacher expressed her gratitude: “I have been teaching logarithms for years, and yet I have never really understood the concept, until today.” Dienes summarized his methodology and his vision about reforming the education of mathematics in his book *Building Up Mathematics*, which was first published in 1960 and became a big success. Many universities invited him and welcomed his research, including Jerome Bruner from Harvard.

Recovering from the Sputnik crisis

“When the Russians launched Sputnik into orbit it was like a shock to the Americans, who liked to think of the Soviet Union as some kind of barbaric, Asian country” – says Sándor Klein. The American leadership blamed science education, and started spending record amounts of money to realize educational reform. Dienes’s findings about how mathematics lessons are largely ineffective and hated by students fit into this reform effort nicely. Thanks to all of this, the so-called “New mathematics” movement, spreading from the early sixties to the mid-seventies, enjoyed the support of the United States government.

But even among the reformers there was no consensus. Bruner, for example, regarded symbols and the language of mathematics important and was reluctant to accept Dienes’s view that these can scare students away from the subject and hinder understanding.

Dienes was not satisfied with the reform. He thought that it was beneficial only for the top five to ten percent of students, but for everyone else it offered only a new subject material delivered with the same old bad methodology. His suggestions were hardly built into the reforms because, among other reasons, they were regarded as unrealizable.

In the meantime, the Dienes Logic Blocks were completed consisting of colourful plastic forms of various sizes, a tool inspired by the experimental tools of the famous Soviet psychologist, Lev Vygotsky. This is one of the most famous of Dienes's inventions and in Hungary is the only one that is still widely used.

The conquest of Oceania

An important station in Dienes's life was the four years he spent in Australia, working at the psychology department and the education department at the University of Adelaide. Together with Malcolm Jeeves, an expert in cognitive- and neuro-psychology, they were trying to determine whether it is easier to learn a complex structure first, followed by a simpler one, which is contained by the first, or the other way around. For example when they examined the teaching of arithmetic operations on paper with multi-digit numbers, they found that starting with the more complex structure was helpful. They began with teaching the concept of ratios, and then introduced multiplication and division as special cases. They did the same thing with fractions, decimals and percentages as well.

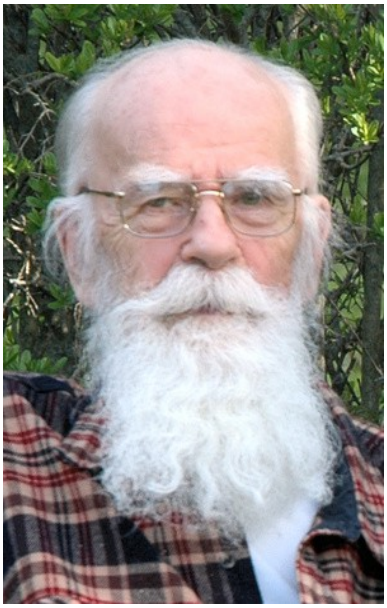
Once again, the experiment became very popular in the local school system. Even the parents took notice, and began to inquire why it was possible to learn interesting maths in

some classes, and not in others. At some point the parents became so enthusiastic that they handcrafted all the necessary tools in a single weekend. Teacher training started in Australia as well, the ministry of education supported the initiative. Even the media became interested: an Australian channel produced six thirty-minute episodes of how children can solve mathematical problems with simple tools. The episodes were aired in prime time.

This is when the invitation came to try this method in New-Guinea. And so, we have arrived to the crocodiles. The crocodiles made their way into the learning process as well in a game where ports were established, and the children could take the roles of crocodiles and kangaroos. This way they examined which places were reachable on dry land, and which ones from the water. The point of the game was to lay the foundations of topological concepts like *inside*, *outside* and *continuous.* However, the methodology could not be easily fitted to an environment so different. Many teachers struggled to understand the purpose of the games, and some simply wanted to make the children memorize the attributes of the pieces of a set like this: “this one is a big red square” – the kids had to repeat. Sometimes the lack of understanding was demonstrated in even scarier ways. One time Dienes was confronted by a Papuan man who had arrows, a bow and a lance on him: “What are you doing with my son? When I was his age I had four killings to my name!” – he said, and showed his necklace made of human fingers. Dienes managed to get out of this frightening situation. He pointed at an airplane soaring through the sky above their heads and said that the children were playing now so that one day they could pilot one of those. Perhaps this is a good example of the slightly naive kind of idealism he had.

Effects of the Trojan horse

He was invited to establish the Psychomathematics Research Centre at the University of Sherbrooke in Quebec, Canada. Thanks to the support of the state and the federal government he had more than a quarter million dollar fund to further his research on the psychology of mathematics learning. In the meantime, his experiments continued in the United Kingdom, France, Hungary, Italy and Germany. “Never since have I found a leader too creative for his own organization” – remembers Sándor Klein, who worked at Sherbrooke in 1972-73. He was able to meet Dienes thanks to Tamás Varga, a great reformer of Hungarian mathematics education, and a leader of the experiment on complex mathematics teaching.



Klein’s work was to verify the effects of the Hungarian reforms; that is why he was invited by Dienes.

Dienes called his own method a Trojan horse: reforming mathematics education was just an opportunity – the real objective was to facilitate the development of young personalities. One result of playful mathematics education was that kids began to enjoy the lessons, and they learned the compulsory material of the regular classes as well. Another effect was that they started viewing unfamiliar problems as challenges, whereas in the control groups, tasks that were different from what they had encountered in class frightened and paralyzed most students. Since Dienes’s games required cooperation, a significant improvement in social skills was also verified.

The limitations of idealism

The methodology that flourished and enjoyed support in the 60's and 70's slowly became marginalized. Dienes could not find his place in the North American power structure. This is where he had to face the practice of giving Ph.D. degrees not according to personal merits but what was "politically correct" at the time. He did not follow this practice, neither did he hold his criticism back from the university's dean. The fact that the schools participating in his research showed exceptional results was not enough to stop this conflict from escalating, and finally his contract was not renewed, supposedly due to the university's tight budget.

He had to make changes: he moved with his family to Manitoba, where he worked with native teachers and children at Brandon University. However, under the flagships of efficiency and thrift, here he was supposed to prepare native teachers to use his method with only a six week seminar. These expectations were unrealistic and unacceptable for him, so he moved to Europe. For some time he went back and forth between the United Kingdom and Germany, doing experiments with schools, training teachers at universities. In Italy, he was entrusted with the creation of a series of textbooks for the elementary schools. In this work he had to maintain a careful balance between what was psychologically correct and commercially appealing. At first it seemed like he succeeded at that, but in later editions the force of the market distorted the books into something that carried only the appearance of a modern approach, but was quite conservative – although more marketable – in its essence. Finally, they moved back to the American continent: he retired to Wolfville, Nova Scotia. This is the home of Acadia University and he was invited to give courses in his methods to teachers studying in the education department, and demonstrations in local schools. He also continued his professional tours in Europe. He continued to publish into his 90's.

In 2007, when Bharath Sriraman, a professor from the University of Montana, asked Dienes why his method was pushed back in many places, he answered that it was because his ideas were not politically appealing. Bruce Dienes, one of Zoltán's sons, spoke of a Brazilian experience: after his father had achieved the same results in a regular school in a poor area that he had previously achieved in a specially selected school, he was never invited back. "It would have been politically volatile to treat a population regarded to be less intelligent in the same way as the elite," said Bruce.

Another obstacle was the fact that his method created a new power structure within the classroom. The teacher was no longer the sole source of knowledge, and thus their authority lost its foothold. Many teachers were scared away by the prospect of losing their power and the control that it meant. A problem specific to the United States was that the students were much more able to grasp the mathematical structures – for example they could do calculations in a base 4 numeral system just as easily as in the regular base 10 system – but the teachers could not keep up with them. Sándor Klein encountered another fundamental objection during his classroom visits, namely the concept of playful teaching. "Many had the approach that kindergartens are for playing, schools are for learning, and workplaces are for working. This artificial separation is highly inappropriate," he says. According to Klein, the method was not able to take root permanently except for a few places, the main reason of which is that teachers cannot be forced to play. Dienes also put his hopes in the grassroots approach. As Klein puts it: "Learning methods and subject materials cannot be introduced on

a national level. It is not possible to centralize pedagogy. Or to be more precise, it is possible, but failure is predictable."

"I did my best to set children free from the ideological shackles that were put on them." Dienes wrote in the late 90's, also voicing some concerns about his own effectiveness, however: "When I read reports from the 60's, I feel like nothing has changed: could it be that we wasted all that time and public money? After all, the picture is not so different today!" It now remains for others to build on his legacy.

His web site is located at http://www.zoltandienes.com