Harnessing ICT for building a creativity-based society

Creativity is inventing, experimenting, growing, taking risks, breaking rules, making mistakes and having fun.

MaryLou Cook

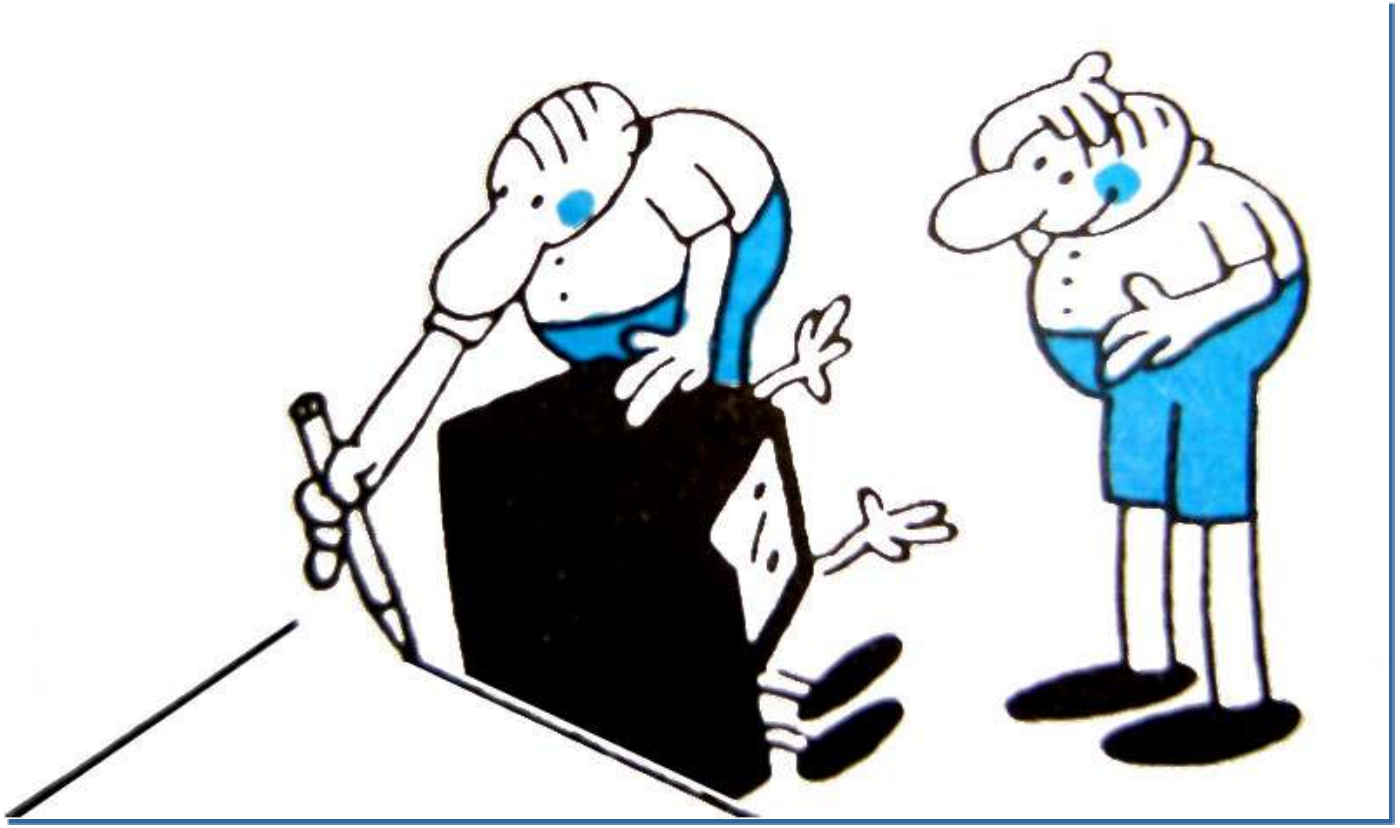
27 – 28 November 2009, Rome, Italy

Pre-computer Era

- Draw a straight line without …!

Post-pre-computer Era

- Draw a straight line with computer!



D. Donev

Expectations

the society vs the educational policy makers

Obstacles to educational change

An Innovative Didactics for Web-Based Learning (IDWBL)

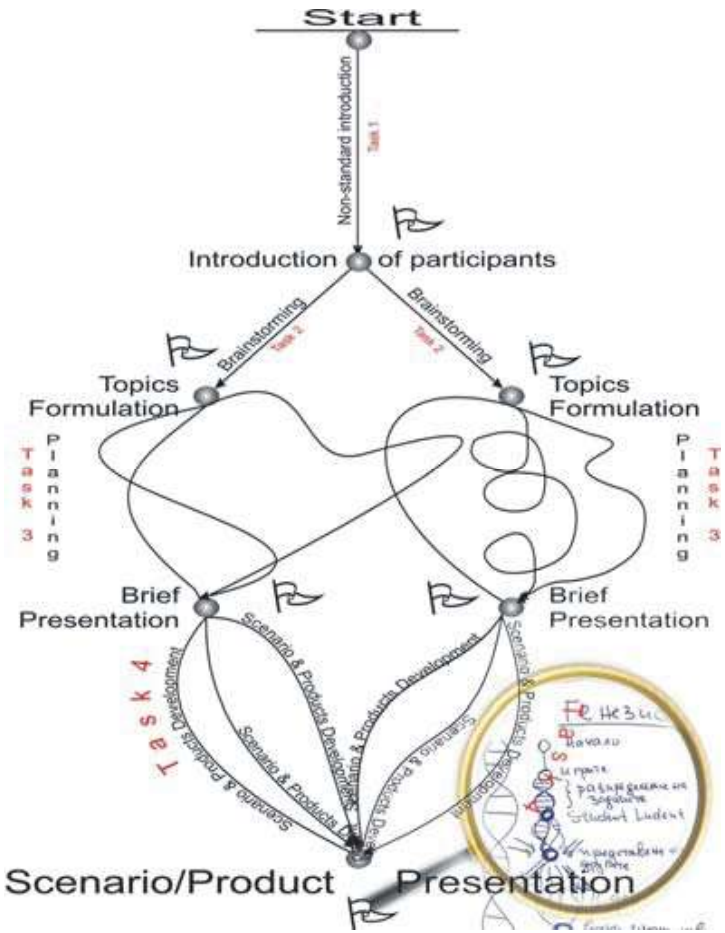
- The web-based learning envisaged in the project comprised five forms:
  - *web referral,*
  - *web quest,*
  - *web exploration,*
  - *e-mail project* and
  - *collaboratory.*

Reports

- *The methodology enables the implementation of various methods for active learning and contributes to the idea that the IT are means rather than a subject to be taught separately.*
- *The teamwork is encouraged thus cultivating a skill very useful in their further life.*
- *The evaluation of the product by themselves teaches the students to be critical and self-critical.*
- *The students are satisfied that they could play an active part in the learning process. This makes them responsible for performing their best during the whole process.*
- *Thanks to the IDWBL methodology the teachers I am training experience the advantages of the teamwork, the learning by discovery and creativity which in turns stimulates them to apply a similar strategy in their own classes*

I*Teach
a methodology for developing ICT-enhanced skills

- *soft skills*
  - *work on a project,*
  - *a team work,*
  - *presentation skills,*
  - *information skills*



Come to our place

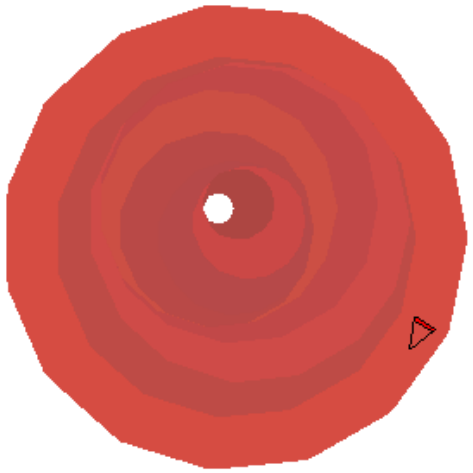
The teachers' feedback was very encouraging

- *I was very happy to see the enthusiasm of my students when they worked on a problem involving processing of data about themselves.*
- *I had implemented many different methods before with no great success. When trying out this methodology with both younger and older students I realized that the main difference this time was that the work was driven by the interests of my students and they were ready to face challenges.*
- *I gave my students an assignment to make a film about our school. They split in teams and distributed their roles. What happened really surpassed my expectations.*

Where to from here?

You must be kidding!

Flourishing as a rose, shining as a jewel



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Изпълнението
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A set of IT textbooks in the style of "hard fun"

The specifics of the textbooks

- Language
- Structure
  - A short introduction
  - The new notions
  - The challenge
  - Creative tasks
  - Amusing stories
- The paths
- The spirit

Some examples of interdisciplinary scenarios

Visual poetry and acrostics

Челюсти веднаж
затрака към ед-
но мишле котака:
— Хайде с мене
към съда, тъжба
дето съм подал.
Няма да ми въз
разяваш! И да
ми се оправда-
ваш. Тръгвай
с мене без
слова. Мишката
отвърна плаха:
— Де вината ми
съзряха?
Що за съд
ще е това:
Без защи-
та, без при-
съда? —
Стига вече
тоя плач.
Аз ще бъ-
да твой
палач.
Твой за-
щитник
аз ще
бъда —
Аз, ко-
такът
мило-
сърд!
И осъ-
ждам
те на
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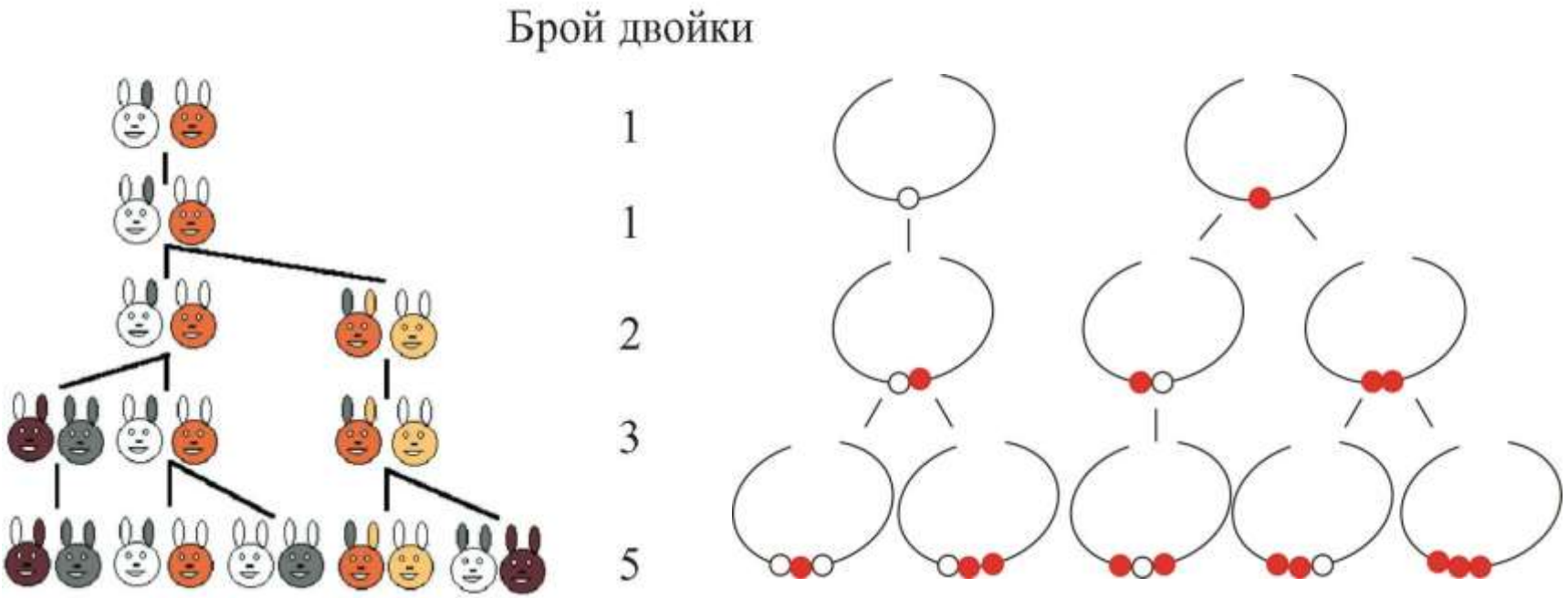
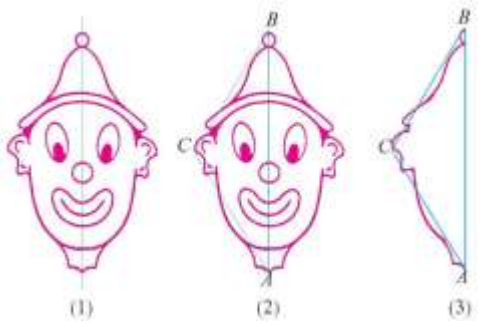
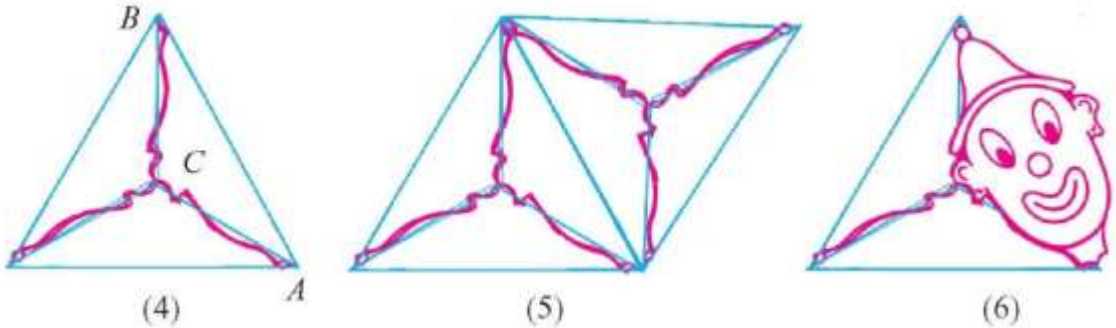
Атрактивна
Ласкава
Искрена
Смела
Активна

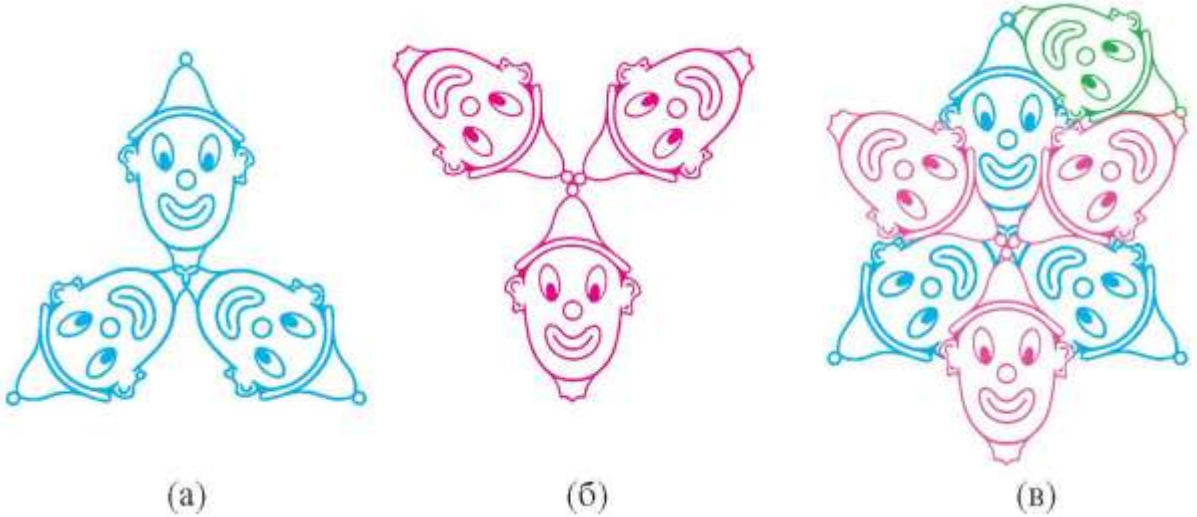
The rabbits, necklaces and Fibonacci



Visual Modeling in the style of Escher







ELICA - DALEST

(1)

(2)

Cesar's code

AB6

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG
1	Кодиране с отместване																																
2	а	б	в	г	д	е	ж	з	и	й	к	л	м	н	о	п	р	с	т	у	ф	х	ц	ч	ш	щ	ъ	ь	ю	я	а	б	в
3	г	д	е	ж	з	и	й	к	л	м	н	о	п	р	с	т	у	ф	х	ц	ч	ш	щ	ъ	ь	ю	я	а	б	в				
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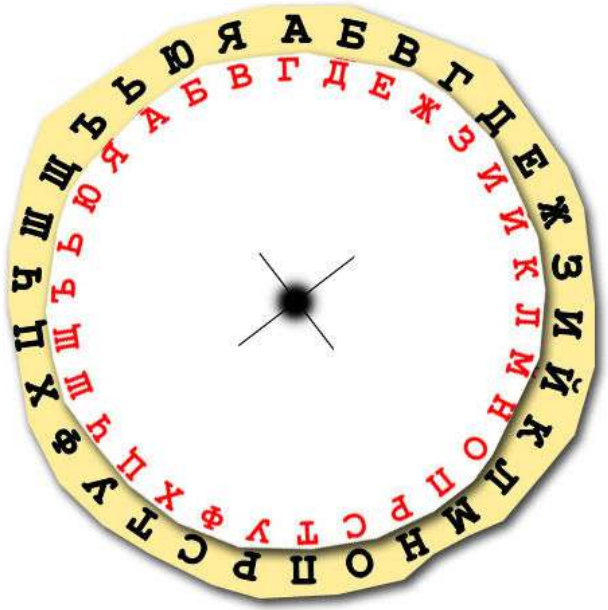
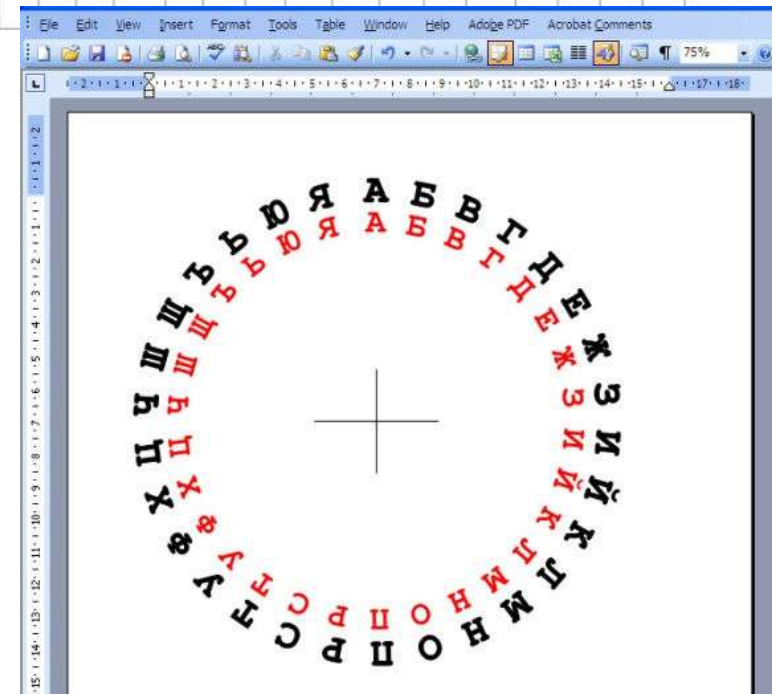
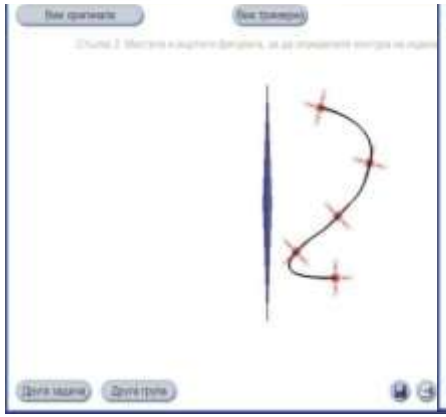


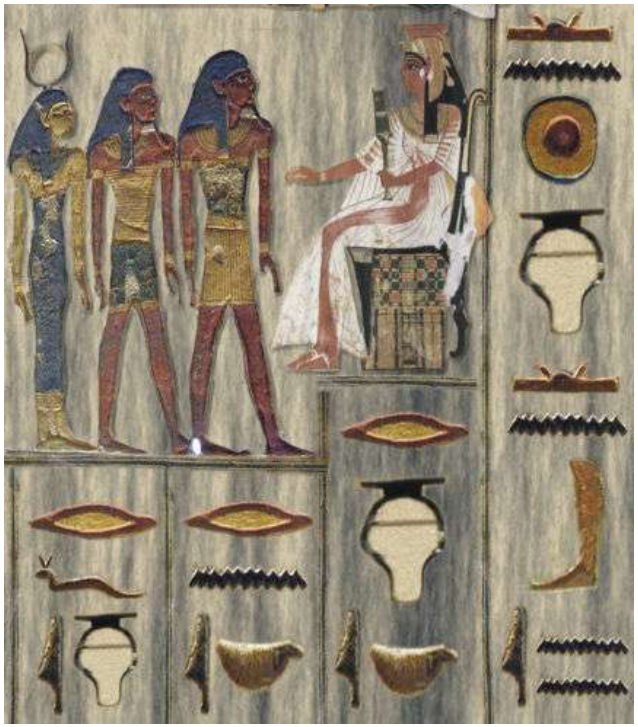


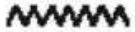
The grand finale

The challenge of restoring ancient vessels



The coded message and a fax with the translation



	В, вътре		Море
	Вино		Обикалям около
	Вода		Псиктер
	Делфин		Скачам
	Кратер		Слагам, поставям

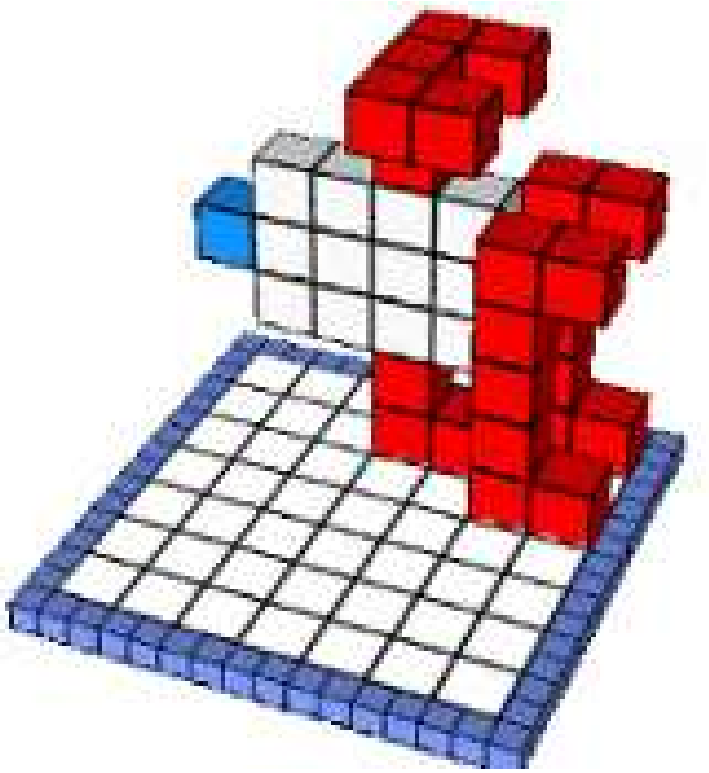
Факс с превод на йероглифите

Wine cooler

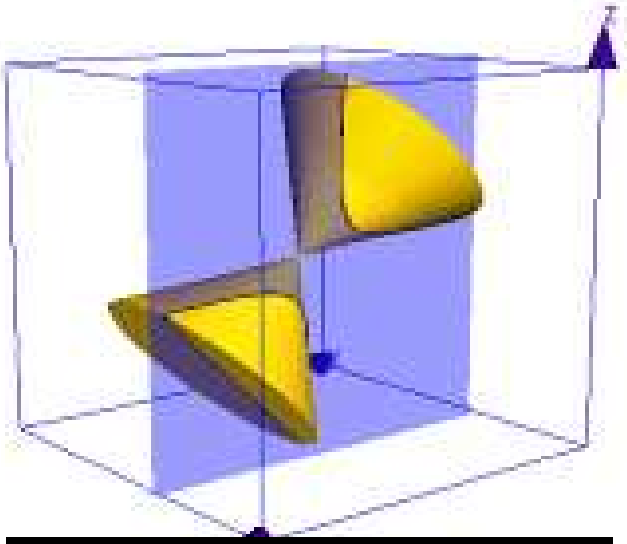
Creativity expected, creativity unexpected

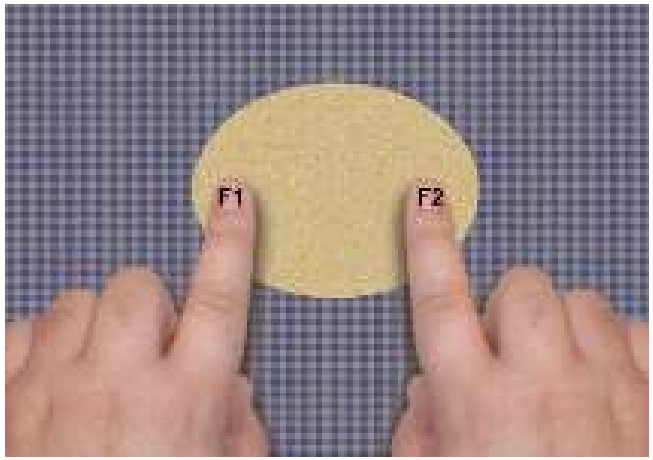
in the context of software applications

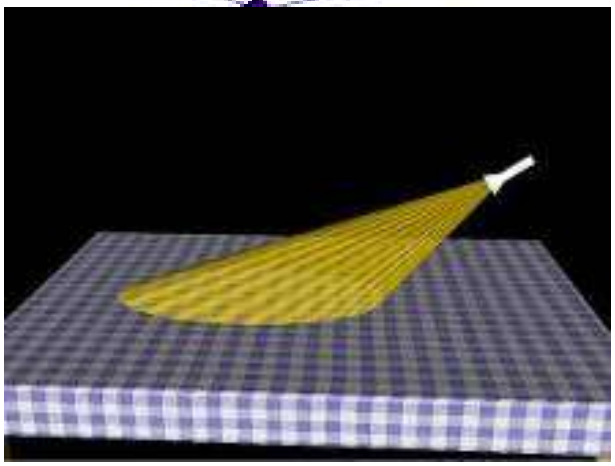
Re-discovering the 3D coordinate system



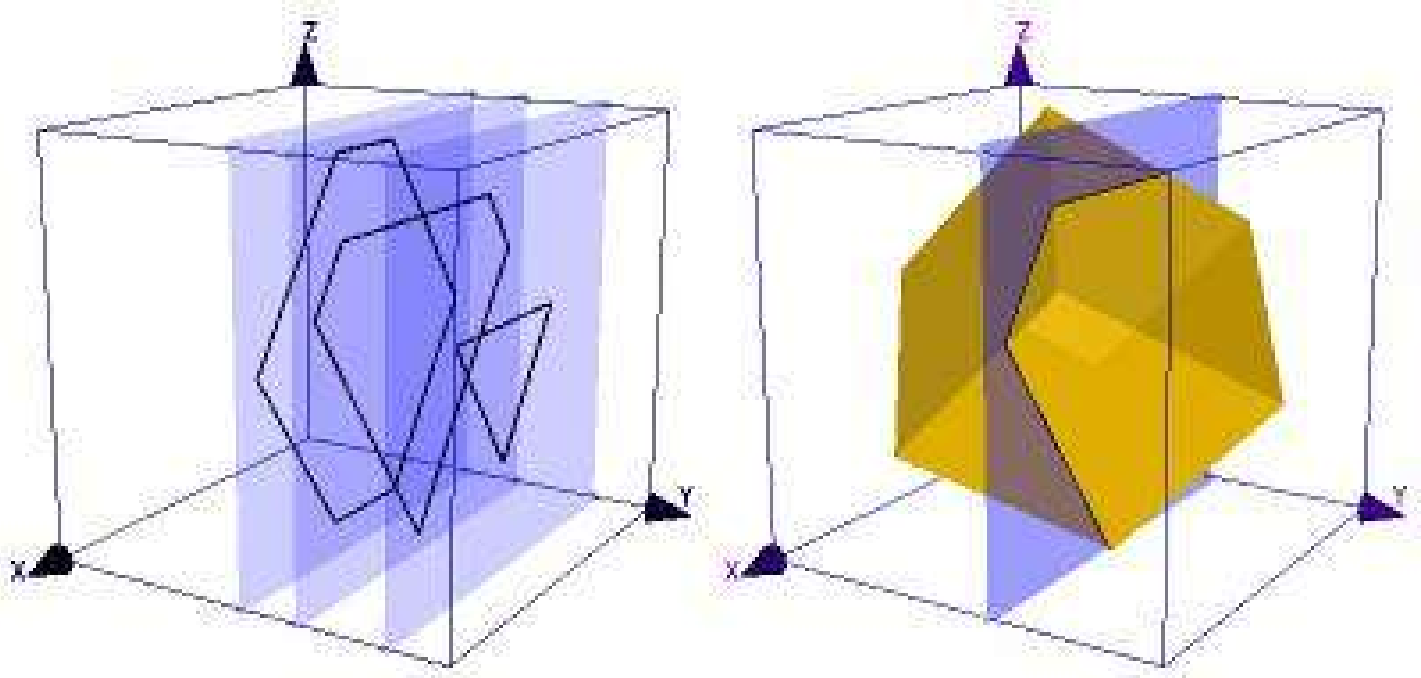
The more it changes, the samer it gets





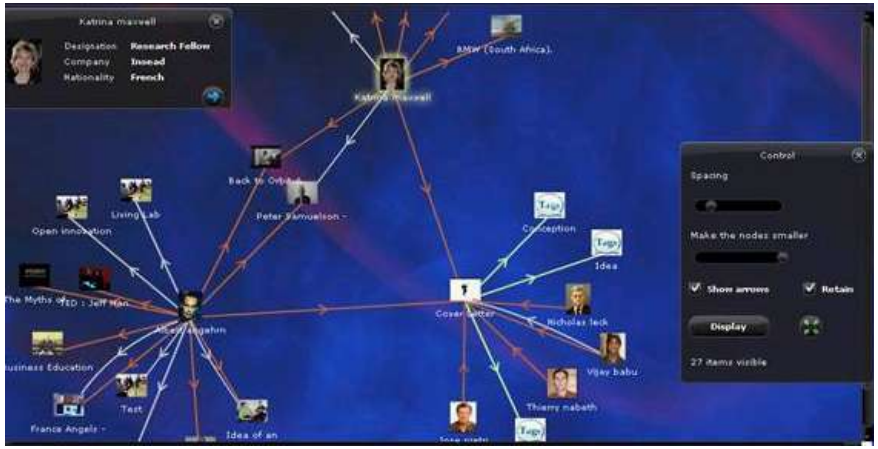


If a cubical meteorite passes through Flatland how the poor Flatlanders might observe this astronomical catastrophe?



Evaluating creativity: a long-term process

- Social networks – a promising mechanism for establishing a feedback
- Assess the stability of the results



E. Sendova,
N. Nikolova, E. Stefanova,
P. Boytchev, E. Kovatcheva

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Harnessing ICT for building a creativity-based society

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Creativity is inventing, experimenting, growing, taking risks, breaking rules, making mistakes and having fun.

MaryLou Cook

1. Introduction

In an age whose dominant value is rather pragmatic and the ICT education is often reduced to acquiring technical skills the main challenge for the educators is to prepare their students to be dignified citizens of a society based not only on knowledge, but on creativity and innovation.

Since every individual sees bigger changes every few years than previous generations had seen in a lifetime it is crucial for today's students to acquire *skills needed to participate with understanding in the construction of what is new* [1]. Thus one of the most important aspects of the education towards a creativity-based society is to provide situations the teachers have never experienced before and thus to provoke them into becoming authentic co-learners joining their students in explorations.

Such a goal puts serious requirements for the education (traditionally teacher-centered one): to provide appropriate strategies, methods and environments, which nurture, enrich and stimulate learner's creativity and afford opportunities for creative interactions.

In an attempt to give possible answers in this direction we have been involved in designing and developing specific ICT-enhanced methodologies, computer applications, a set of ICT textbooks, and didactic scenarios in the frames of recent European projects [2] (I*Teach – *Innovative Teacher*, DALEST - *Developing Active Learning Environment for Stereometry*, IDWBL - *Innovative Didactics for Web-Based Learning*, TENCompetence - *The European Network for lifelong Competence Development*, InnoMathEd - *Innovations in Mathematics Education on European Leve*l). Below we share some impressions of implementing them within ICT-based teacher training courses and in class settings in Bulgaria, and focus on specific examples of creativity shown by teachers and students. Part of being creative is not to be afraid of challenges. Let us first throw a glance at some typical ICT-related challenges the Bulgarian teachers have been facing in recent years.

The ICT have been introduced as a separate compulsory subject in the Bulgarian curriculum for the junior high school since 2005 starting with 5th grade. This lead to the necessity of *converting* many teachers, specialists in other disciplines (mathematics, science, art, etc), into ICT teachers.

The first serious problem the ICT teachers are facing is the conflict between the expectation of the society and those of the educational policy makers. On one hand, the society expects from the future citizens interdisciplinary and *soft* skills needed for achieving a variety of real-life goals; on the other - teachers have to follow a strict curriculum according to the educational standards in a relatively limited time and in a fixed order. Another important problem is the great variety of preliminary ICT knowledge among the students in the junior-high school. This leads both to the lack of motivation for those who have already acquired the expected technical skills prior to the introduction of ICT at school, and to a feeling of intimidation for the rest. Furthermore, while the emphasis of the teaching is put on the technology itself it is normal that the teachers would stick to *the good old preaching style* thus demotivating additionally the students. When offered to use active learning methods to overcome this demotivation the teachers would usually refer to the lack of: appropriate materials, relevant evaluation mechanisms, and sufficient time.

As for the teachers who are officially "non-IT teachers" it is rare the case that they would use IT in their classes. Still we don't share a common view that *the most difficult obstacle in the way of transforming school would be the teachers*. We support the view of Papert [3] that *this simplistic belief is in reality a far greater obstacle to educational change than the fact that some teachers actually are conservative*.

During the numerous teacher-training courses and workshops we have been involved in, we would take any opportunity to convince the teachers that they could be innovative and creative. This was best achieved when we introduced to them methodologies designed and shaped within the IDWBL Minerva project [4] and the *I*Teach* (*Innovative teacher*) Leonardo DaVinci project [5]. Here below they are presented in a nut shell.

2. An Innovative Didactics for Web-Based Learning (IDWBL)

The methodology developed in the frames of the IDWBL project addressed teachers in all subjects of the secondary school by providing them with assignments having a specific structure. The web-based learning envisaged in the project comprised five forms: *web referral, web quest, web exploration, e-mail project* and *collaboratory*.

The teachers acquired the methodology by means of the cascade principle, viz. every participant in the pilot courses was expected to share his/her experience with ten colleagues and to develop five assignments to be experimented in a class setting. A data-base of assignments available via a specially developed Internet platform (WAD) was dynamically created, refined and modified.

As a whole the analysis of the project results has shown that WWW has a great potential for supporting the learning/teaching process. The WAD base is very helpful for the teachers with the resources offered in it. Thanks to such a base and to the innovative pedagogical approaches they have been sharing their good educational practices and enriching their traditional work in class. The teachers have reported the improvement of the thinking process of their students and their enhanced motivation for learning. Here are some fragments of these reports:

- *The methodology enables the implementation of various methods for active learning and contributes to the idea that the IT are means rather than a subject to be taught separately.*
- *The only problem for me as a geography teacher was that I didn't feel competent enough about my IT skills. It was due to the motivation and the good attitude of the kids that I had the courage to implement the new methodology. The IDWBL project stimulated me to continue my qualification and I took a training course for IT teachers to be.*
- *The teamwork is encouraged thus cultivating a skill very useful in their further life.*
- *The evaluation of the product by themselves teaches the students to be critical and self-critical.*
- *The students can see how interweaved the different disciplines are and to appreciate their application in real life situations.*
- *The students are satisfied that they could play an active part in the learning process. This makes them responsible for performing their best during the whole process*.
- *Thanks to the IDWBL methodology the teachers I am training experience the advantages of the teamwork, the learning by discovery and creativity which in turns stimulates them to apply a similar strategy in their own classes*

Still there were some important problems to be solved. The teachers from the country found it difficult to work with insufficient equipment, slow Internet connection, the noisy atmosphere while working in a team. They shared with us that their students were lacking skills to process information, to look for relevant resources, to work in a team, that it was not easy to evaluate the individual members of the team. Some of the suggested forms (e.g. *collaboratory*) turned out to be difficult to implement in Bulgaria. We realized that most of the teachers were not ready to use independently the IT in their classes and the best effect was achieved when a non-IT teacher collaborates with an IT teacher. A further step in our teacher training activities was to enhance the self-confidence of the teachers by putting them in the role of active learners and help them reveal their creativity potential.

3. *I*Teach* – a methodology for developing ICT-enhanced skills

The *I*Teach* methodology is based on active learning methods, the teacher being a guide and a partner in a project work following didactic scenarios designed to encourage the creative thinking of the learners. This methodology focuses on the development of specific *soft skills* in the context of the ICT education: *work on a project, a team work, presentation skills, information skills*. These four groups of skills have been identified as the most important ones by the representatives of the countries participating in the *I*Teach* project (Bulgaria, Germany, Italy, Lithuania, Netherlands, Poland, Romania) [6, 7]. The notion of *ICT-enhanced skills* has been defined in it as a *synergy between the technical and the soft skills* expected to be transferable skills in the Life Long Learning society.

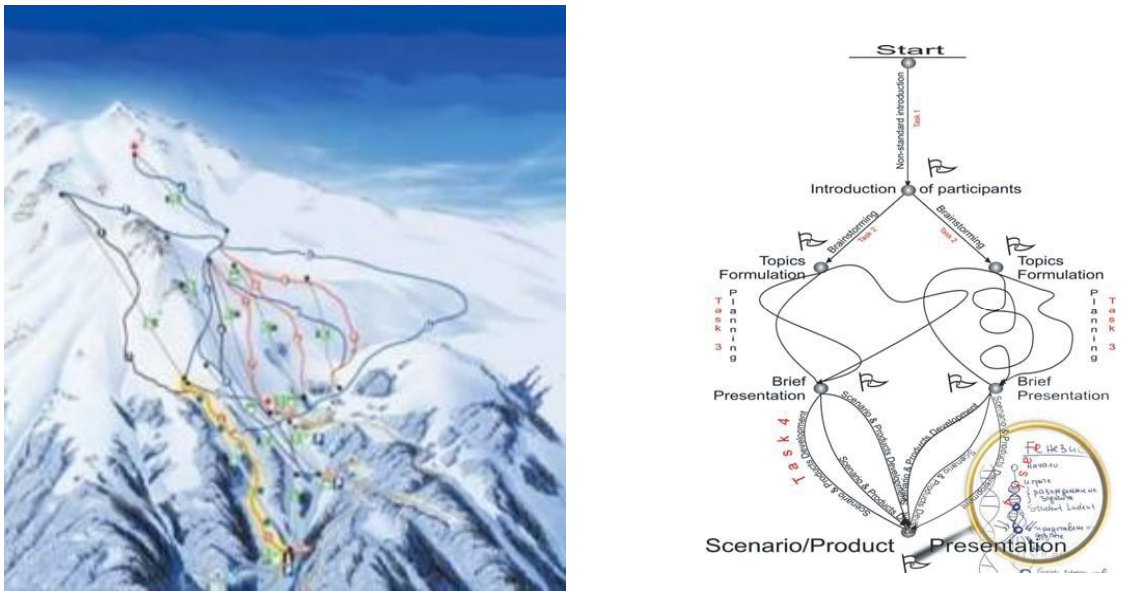


Fig. 1 A roadmap metaphor of the *I*Teach* methodology

Our experience in applying the *I*Teach* methodology shows that it contributes to learner's creativity in two main directions: (i) by stimulating the achievement of the final goal, viz. creating a product, ready to be presented, used and shared (the "stimulating" component of the methodology is implemented by setting intermediate sub-goals, *milestones*, to be covered by the learners towards the final goal); (ii) by stimulating learners to choose their own way to the final goal passing through the milestones. Introducing the *I*Teach* methodology worked best when we did it at a meta-level [8, 9] and illustrated it with a roadmap as a metaphor (Fig.1).

At the beginning of each teacher training course within the project we would launch a general enough topic for a brain storming. The participants would write down their interpretations and associations with the theme as sub-themes on the board and then form teams according to the expressed interests. Here are some examples.

3.1 *Come to our place*

When working on this topic the participants reached themselves our metaphor of the *I*Teach* methodology – they represented the final goal as a peak, the road to which is a matter of choice, and along the road there was a red cross station (personalized in this case by us in the role of teacher trainers) in case someone needed help.

The teacher in popular customs experimented in parallel the methodology with her students and demonstrated the results to us the very next day – models of their dream yards (Fig. 2.)

Fig. 2 Products of young students on the theme *Come to our place* (*My dream yard)*

Another interesting idea was the project for organizing kick-off meeting with presenting different nationalities. Costumes, dances, songs and l cuisine of several nations were the context in which the participants demonstrated creative skills in integrating virtual and more traditional technologies. The final outputs of this project included the delicious food decorated with lucky rimes in educational context. It was especially rewarding for us to realize that many of the participants had tried out the project ideas in a class setting immediately after the course. Furthermore, some of them had organized their own family fests influenced by the inspirational atmosphere of playing with ideas how to enjoy the preparation of the party and how to provide creative opportunities for their guests.

Fig. 3 The national cuisine products within the theme *Come to our place.* The cake is with the project logo.

The teachers' feedback was very encouraging:

- *I was very happy to see the enthusiasm of my students when they worked on a problem involving processing of data about themselves.*
- *I had implemented many different methods before with no great success. When trying out this methodology with both younger and older students I realized that the main difference this time was that the work was driven by the interests of my students and they were ready to face challenges.*
- *I gave my students an assignment to make a film about our school. They split in teams and distributed their roles. What happened really surpassed my expectations.*

The next course based on *I*Teach* was with pre-service teachers at the Faculty of Mathematics and Informatics and we offered them a theme we hoped they would find appropriate for a brain storming.

3.2 *Where to from here***?**

This theme was first met with skepticism however: *What? Another Power Point presentation? We already know how to make one! I didn't get what you expect us to deliver at the end… Whatever you like. Didn't you get it – there are no rules here!* These were the first comments before we launched the real brainstorming: *Let us think of situations at which such a question arises.*

At the end the following subtopics were formulated: *How to make both ends meet, Work, Pets, The global warming, How to reach the desired weight, Urbanization.*

The products included computer presentations, inquiries, documented interviews in a park, video-films. It was very rewarding for us (as teachers) to witness the creative approach of all the students who would gain courage in the process of developing their projects and play with ideas of various nature. The film *How to make both ends meet* for instance discusses how to save money for expensive perfumes, luxury food, fashionable clothes, hard drinks and fitness by offering non-standard ideas with sense of humor. The participants in this project worked as a team involving the typical professions: writer of the script, actors, cameraman, musicians, and technology experts. It is worth mentioning that the technology was not the focus of the project, it was just facilitating the distribution of authors ideas which originally were to make it as a sketch theater.

The topic of choosing a path in life (as was the interpretation of some of the participants) seems to be even more challenging for the last year high-school students. *When offered to work on this topic*, as an in-service teacher shared with us, *it turned out that the main problem is not lack of "hard" or "soft" skills but the lack of life-orientation. Nobody had seriously thought before what path to choose in terms of job, profession or further studies…*

The good news is that thanks to the teachers' support the students could find their real vocation. Here is a story experienced by the second author:

A few months ago I got an invitation by a young man via Facebook who introduced himself as a former student of mine. He reminded me that he had studied in the National Math&Science school – the biology branch 7 years ago. Sasho (this was his nick name) shared with me the most memorable for him school event – the attempt of his class to soften my intention to give them a test on 1st of March (the Bulgarian fest of the upcoming spring celebrated with the so called *martenitsa*, a small piece of adornment, made of white and red yarn). *As I remembered my condition for a non-test celebration was that each one of them would make a martenitsa for me.* How? We don't have materials at hand! – *was the first reaction of the students but then they looked around and realized that the computers could save the situation. At the end of the session I had all kinds of non-traditional martenitsa – in the form of graphics, poems, even animation! As Sasho proudly reminded me his was the best one – an animated sketch of two folk characters. And only now I remembered of having shown it to the whole class as an example of creative solution.* After three years suffering at the medical university, *Sasho went*, I realized that my real vocation is the web design and here I am – a member of a prosperous company in the field. *His request was to continue our professional discussion on IT related problems.*

3.3 *Teach=Learn* (*You must be kidding!)*

In the last grade of the specialized schools in Bulgaria the teacher can choose the technology and the programming language to work with. One of the teachers having already rich experience with the *I*Teach* methodology *took the gauntlet thrown down* by a colleague to use *Rich Internet Applications (RIA)* with *Adobe Flex* of which she had only vague idea. When introducing her plans to the students the reaction was not very encouraging: *Why not C#? We prefer Java. Why something so difficult – we haven't heard of it…* The teacher explained that it would be much easier for her to teach C# or Java since she had been not only programming in them but also teaching with them. She also pointed out that the RIA technology was so recent (the version to be used had been published only in 2008) that there was no literature in Bulgarian language and that it is taught only in some specialized courses in several universities in the country. And what was the most important – she herself didn't know it and was prepared to learn it together with her students. The students were amazed and speechless for a while before bursting out in a single question*: Are you serious?* The teacher shared with them her plan in details – that they would be like a research team, looking for the relevant resources, experimenting and debugging together, writing down what they had learned and the problems they had come across. The enthusiasm was growing as the students were imagining the process. Some of them reported that they had found online tutorials, others were looking for appropriate books, and some others were reading about the advantages of *Flex* and wondered if not knowing *Action Script* would cause problems. Currently, after 6 sessions, there is an e-course on the subject in Moodle with a basic book, a presentation sample, a schedule for presenting sections of the book (already in

Bulgarian), a list of resources and even problems with submitted solutions. The lecturers take shifts on a rotational principle, each one presenting the latest topics learned and the main problems faced. The teacher's role is to generalize at the end of the session what has been learned, to add it in Moodle, and to announce the next topic. During the rest of the time the teacher tries out various ideas on her computer and checks the progress of the students.

To prove that they are good learners the teachers are expected to do a lot of learning in the presence of their students and in collaboration with them. Such a style of teaching is still very rare but this is what the paradigm for the 21 century education envisages – students and teachers are partners in research teams, they collaborate, they teach to and learn from each other.

3.4 Flourishing as a rose, shining as a jewel

During a course for qualifying engineers to become teachers in mathematics and informatics there were two women with very modest technical skills, practically lacking experience in working with IT. After interviewing the participants about their hobbies we realized that the first one was very fond of flowers, particularly roses, and the other was dreaming to be a jewelry designer. This determined the topic of their projects. Being motivated by working on projects of a personal interest they worked very hard and learned how to integrate various IT tools. Not only did they learn how to search for relevant information on the Internet and how to use presentation- and graphics software but they also wrote some Logo programs to animate a flourishing rose and to design a necklace and bracelets decorated by fractals.

No matter how good the results of the pilot testing of an educational methodology are it couldn't be implemented without appropriate textbooks tuned to the interests of the students and to the expertise of the teachers. With this in mind, a set of ICT textbooks for 5th, 6th and 7th grades have been developed (the authors of this paper being part of the developers' team) which not only cover the requirements for building ICT skills for that age but allow both the students and their teachers to express themselves in various fields [10-12].

4. A set of IT textbooks in the style of "hard fun"

The concept of "hard fun" has been expressed in many different ways, all of which all boil down to the conclusion that everyone likes hard challenging things to do [13]. But they have to be the right things matched to the individual (students and teachers alike), to the specifics of the time and the national traditions. The idea of writing textbooks in such a style was itself a challenge for us as educators, since our textbooks had to connect with the children and also with the areas of knowledge and skills they would need for the creativity-based world. At the same time we had to think of the teachers giving them the chance to take advantage of their original field of expertise.

Fig. 4: The textbooks: *The computer in my world; I am learning and creating with a computer; You and IT*

4.1 The specifics of the textbooks

- **The language** is tuned to the age specifics. A special attention is paid to the lessons' titles which are short, understandable and intriguing (unlike the tedious and too technical titles from the standards). Compare our title *How to format a text as a long and a sad mouse tail* with: *Formatting the text at a paragraph level. Setting up the properties of the pages in a text document. Numbering of the pages*. Let us note that each lesson title is in the form of a question whose answer is to be revealed by the students in the learning process.

Furthermore, the titles of the textbooks themselves are oriented to the young readers putting them in the role of creative partners of the authors and the teachers: *The computer in my world, I am learning and creating with a computer, You and IT* (Fig. 4)

- **The Structure** is as follows:
  - **A short introduction** in which the main objectives, both technical and soft skills to be acquired, are specified;
  - **The new notions** in Bulgarian and English language;
  - **The challenge** - a creative task motivating the introduction of new knowledge and skills, stimulating students to find and describe different ways to the final goal

Fig 5. The challenge: how to preserve the national inheritance by means of ICT

- **Creative tasks** spread in several subsections, e.g. *Roll up your sleeves, Give free rein to your imagination*, etc
- **Amusing stories**

Typical for the structure of textbooks is that there is a common thread linking the tasks in a lesson (5th grade); the lessons in a common ICT theme (6th grade), and the ICT themes in the whole textbook (7th grade) in specially designed didactic scenarios.

- **The paths** to solving the challenge are various. To prepare the students for citizens of the knowledge/creativity based society we try to encourage them to discover various solutions to the problem and compare them according to specific criteria (rather than to apply recipes in the style *click and drag*).
- **The spirit** is friendly and collaborative.

Although all the textbooks share the same features there is specifics in each one of them related to the age of the students. For instance, the interactivity is achieved in 5th grade by introducing two sympathetic characters (a boy and a girl with whom the learners might identify themselves) who are ready to ask about things they don't know or understand and to learn together with the students. In the textbook for the next grade there is a stronger emphasis on the ICT-enhanced skills interweaved in projects of interest to the students and at the same time being more serious and challenging. In addition, the required ICT skills are achieved in the context of interdisciplinary scenarios which could be easily tuned to the expertise of the teachers - mathematics, history, mythology, art, etc. Here are some examples.

4.2 Some examples of interdisciplinary scenarios

Visual poetry and acrostics

The notion of text formatting required by the ICT Standards is integrated in our textbooks in the context of emphasizing the content of a poetic work through its form. For instance, the tale of the mouse (from *Alice in the Wonderland*) is presented in the form of a mouse tail and Alice is described through an acrostic (Fig. 6).

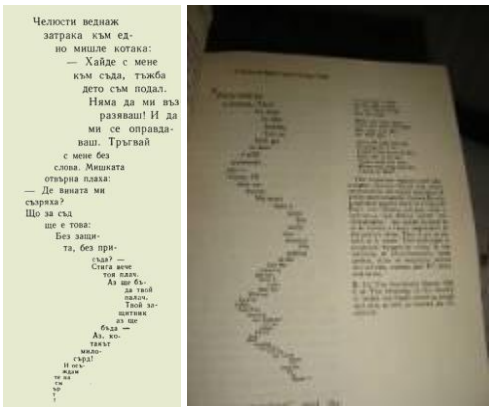


Fig. 6 Formatting in harmony with the content

The students are encouraged to create their own variations (interpretations) of these examples.

The rabbits, necklaces and Fibonacci

This scenario introduces deep mathematical ideas (the Fibonacci numbers) in a real-life context both simple and interesting for the students (Fig. 7).

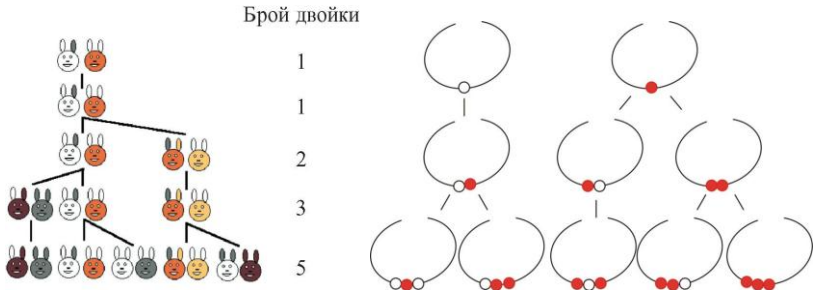


Fig. 7 Fibonacci numbers in the context of grandpa's rabbits and grandma's necklaces

Here the emphasis is not on the introduction of new technical skills (formatting of cells in electronic spreadsheets) but on provoking students' imagination, mathematical thinking and raising their awareness of the relations between abstract mathematical notions, the nature and the fine arts.

Visual Modeling in the style of Escher

The idea of bringing together knowledge from various fields is further intensified in the *Integration of activities* theme (6th grade). A typical example is the introduction of specific tools of a Graphic Editor in the context of tessellating the plane with rather complex tiles in the style of Escher (Fig. 8).

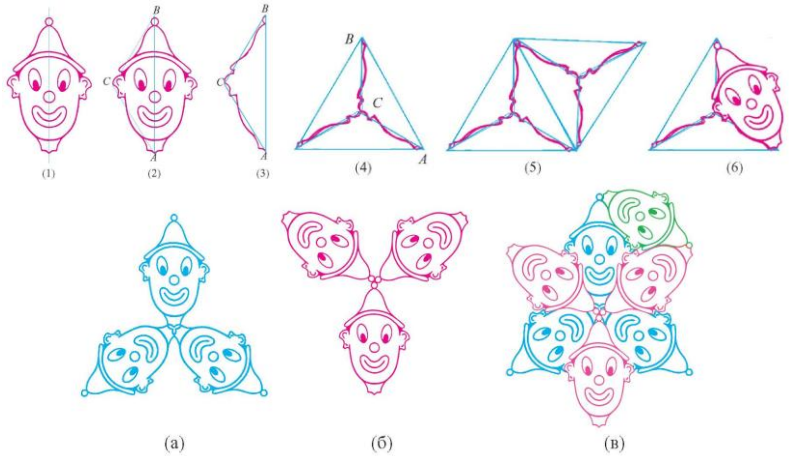


Fig. 8 Tessellating the plane with the face of a clown

The students realize how their mathematical knowledge about symmetry and rotation could be harnessed in art and how it could be enhanced by the ICT tools.

The goal of textbooks and the software is not just to help students learn, but also to help teachers express their knowledge and abilities in the best possible way, viz. in the field of their original expertise. For example, there are projects in 6th and 7th grade in which students combine their artistic skills with their mathematical knowledge by means of various computer applications (Fig. 9).

Fig. 9 Integrating mathematics and arts by means of Elica

The best realization of our approach is the final book of the series developed as a challenge itself with the theme of coding passing as a red thread through the whole content. Even its original title in Bulgarian, **ТИ и ИТ**, is a pun since the first word (you) is the mirror image of the last one (IT) - a way of coding a message. Each lesson deals with ideas and tools for solving problems considered as milestones towards a final goal. For instance additional information about the properties of an electronic table is introduced in the context of decoding messages using the *prisoner's code*. Cesar's code is introduced as a context for implementing new information about spreadsheets and artistic arrangements of text (Fig. 10).

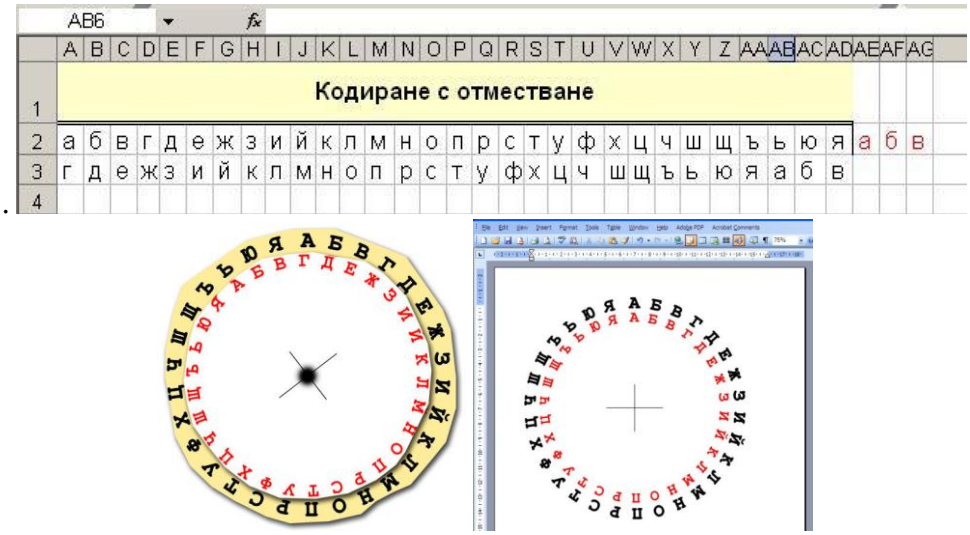


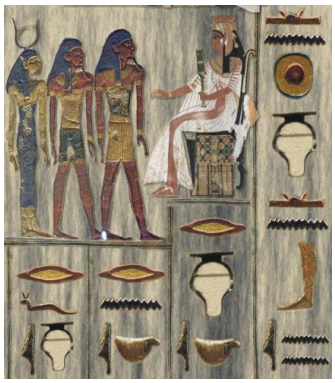
Fig. 10: Various presentations of Cesar's code

Thus each lesson in the textbook for 7th grade provides implicitly ideas and means for solving the puzzles offered by the authors at the end. The grand finale is a project requiring the students to put together all the subject knowledge and skills acquired during the school year and to work creatively in teams for the achievement of a common goal. During the project the students are faced with problems from real life and are expected to understand in a natural way when, how and which ICT tools to apply so as to solve the challenge of restoring archeological artifacts (Fig. 11).

Fig. 11 The challenge of restoring ancient vessels

For the purpose students are encouraged to explore computer models (Fig. 12) and to decode a message (Fig. 13) with hieroglyphs so as to help a local museum to restore ancient Greek vessels and figure out their function.

Fig. 12 The computer model



	В, вътре		Море
	Вино		Обикалям около
	Вода		Псиктер
	Делфин		Скачам
	Кратер		Слагам, поставям

Факс с превод на йероглифите

Fig. 13 The coded message and a fax with the translation

The project is a stand-alone entity in which students are expected to demonstrate their problem solving skills by means of ICT. The project is designed as a prototype of a real large-scale project. Some tasks can be done in parallel, others require sequential execution. The students are expected to split in teams and distribute work forces according to their skills. The resemblance to a real project goes to the level of having teams perform their tasks by designing their approach, then implementing it, and finally, preparing a deliverable which is evaluated by the teacher. The deliverables could also be input data for other teams' tasks. The project ends with a report in which the team presents its work in front of the class. The idea of incorporating project activities into the classroom has goals going far beyond the typical summary. By taking part in the project students learn by experience about the specifics of the team work, the importance of deadlines, presenting their results, and coping with a dynamic collaborative environment. The students gain a valuable experience in demonstrating their work - they learn how to defend their ideas, how to tune the presentation to a specific audience. Skills acquired through this activity are certainly not narrowed to just IT and could be applied further on in various aspects of life.

5. Creativity expected, creativity unexpected (in the context of software applications)

The textbooks were supported by specially designed computer applications based on Elica [14] . They have been developed by the fourth author in the frames of the DALEST project for enhancing the spatial imagination of students [15] and have been successfully implemented also in Cyprus, Greece, Portugal and UK. Teachers are encouraged to explore them not only within the scope of the classroom activities, but in extracurricular activities as well. The applications can be used in a dozen of educational situations and teachers are encouraged to invent new applications of the software. However, sometimes students are the ones that surprise us with stunning creativity.

5.1 Re-discovering the 3D coordinate system

Following specific didactic scenarios 5-graders from Sofia math school had to build a construction in free style the only limitation being the fixed number of unit cubes. Then their task was to describe it verbally in such a way, that it could be reconstructed by another student [16]. This task involved a coherent interrelation between activities of different types, such as mathematical sense of size and proportion, artistic imagination and linguistic abilities to provide a short but unambiguous description.

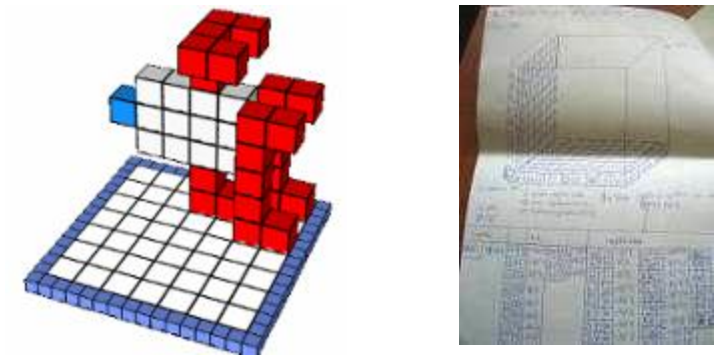


Fig. 14 Discovering 3D coordinate system to describe a fish

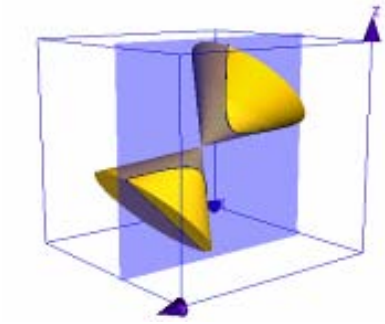
The typical description of a structure comprised a long verbose text, because students were trying to eliminate all possible misinterpretations of their explanation. A totally different approach is shown in Fig. 14. The student had created a virtual fish, but his description involved denoting all cubes by their coordinates in the space. This student had in fact re-discovered the 3D coordinate system, since it had not been included in the curriculum as of that time. The student based his work on the labeling approach of a chess board: for horizontal coordinates he used Arabic numbers and Latin letters, and for the vertical axis – Cyrillic letters. He provided a straightforward elegant table with the cube space coordinates adding the color as a fourth coordinate.

Providing suitable learning environments does support students' discoveries in mathematical context. Of course, creativity is not a subject of fixed prescriptions, so it is impossible to predict how a specific software implementation will affect a particular student in a given situation.

5.2 *The more it changes, the samer it gets*

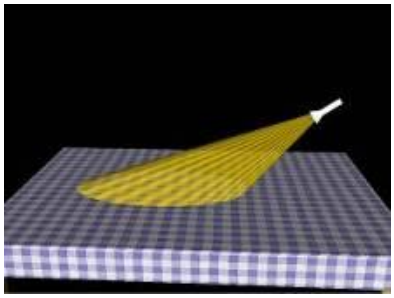
To be creative, and even more importantly - to be open to the feedback of the teachers and students - is very important for the software developer. The next story illustrates how the necessity of multiple presentations of a mathematical concept inspired the author of Elica to create computer applications enabling students to explore the conic sections.

The *Slider* application (Fig. 15a, 16) developed within DALEST project turned out to be very challenging even for more experienced mathematicians. So a new set of complementary applications (this time in the frame of the *InnoMathEd* project [17]) were developed providing a platform for explorations of conic sections much closer to the real world –using the light cone of a torch, studying the shadow of a ball, even stretching pizza dough with the user fingers being in the foci of the ellipse. All the virtual experiments in this set could be replayed later with real objects thus enabling the students to make valuable connections between math and physics, between the virtual and real world.



(a)

(b)



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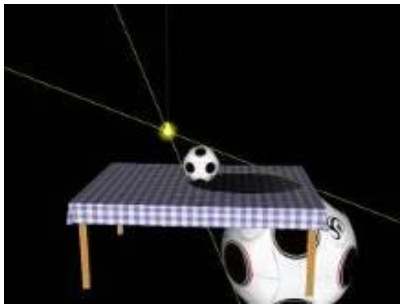

(d)

Fig. 15 (a) A conic section generated by the *Slider* application; (b) an ellipse generated by stretching a virtual pizza dough with the user fingers being in its foci; (c) the construction of an ellipse by using the light cone of a torch; (d) an ellipse made of the shadow of a ball, touching the table exactly at the ellipse's focus; the ball below the table, which is circumflexed by the extended shadow touches the other focus of the ellipse

5.3 Who dares to be wrong?

To write appropriate didactical scenarios for these applications is still a challenge for us but we have started some experiments with them in various settings - young students, PhD students, IT experts and even a photographer passing-by… The first results were very surprising. Let us consider for example the didactical scenario dealing with the inhabitants of Flatland for whom all the objects are planar. The question is: *If a cubical meteorite passes through Flatland how the poor Flatlanders might observe this astronomical catastrophe?*. Of course the answer should start with: *It depends*…(Fig. 16)

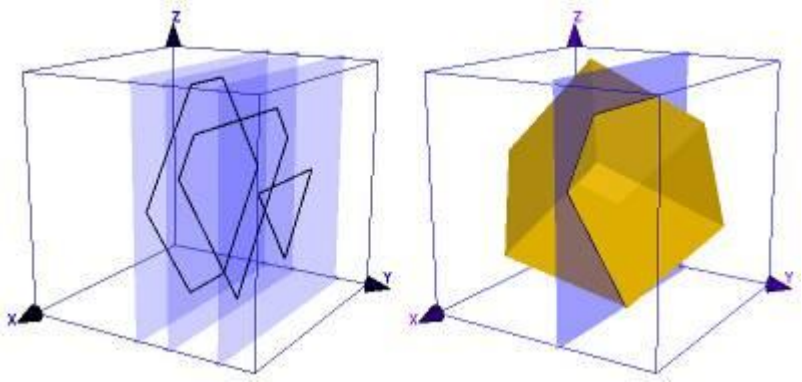

Fig. 16 The unexpected intersections of a cube with a plane

When we present this problem to students – younger and older ones – they would give at least a partial answer – rarely exhausting all the cases. But in the case of experts, say the audience of a recent IT conference, no willingness to answer in public was shown. Everyone stayed silent … except for a person who was not a part of the audience, viz. the conference photographer. He was the only one to solve the problem and to dare to express his reasoning out loud. Even more surprising was that the photographer's actions triggered the audience -till the end of the presentation the people unlocked and surrendered themselves to their curiosity and creativity.

6. Conclusions

Just as we have confidence that the students can do more than people expect from them we have equal confidence in teachers. But to show their potential the teachers need time, intellectual support and resources providing them with the opportunity to learn.

The feedbacks we have got so far makes us optimists – the teachers we have been working with have shown impressive creativity when designing projects and didactic scenarios, and have reported about some impressive discoveries of their own students. Still, a lot has to be done in terms of evaluating creativity. When developing new educational standards for the secondary school IT curriculum we suggested some creativity related requirements to be included. This suggestion was met with skepticism since *creativity is not measurable*. All the same we defended our suggestion. But evaluating both the teachers and the students in terms of creativity is a long-term process. The social networks are a promising mechanism for establishing a feedback. Only then we could assess the stability of the results.

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