STEM TECHNOLOGY EDUCATION

Authors:
Valery Ochkov NRU «MPEI»
Konstantin Orlov NRU «MPEI»
Julia Chudova NRU «MPEI»

Speaker:
Valery Ochkov
NRU «MPEI»
In 1995, Ochkov V.F. spoke at the Council of MPEI with a report on computer programs for training energy personnel. He was asked how he relates to the Informatics course. He replied that he would have read it differently. Ochkov V.F. offered to read this course at one institute of the MPEI. He agreed and has been doing this for 25 years, transforming the course into classes on STEM technology. See please the website =>
About STEM

STEM is an innovative educational technology. In a lesson on modern information technologies, questions of different academic disciplines are considered. These disciplines can be engineering: mathematics, physics, chemistry, thermodynamics, heat and mass transfer, hydrodynamics, theoretical mechanics, material resistance, etc. But humanities are also referred to, for instance, literature, history, political science, etc. In Russia, the terms “interdisciplinary communication” and “cognitive learning” could be more familiar here. The abbreviation STEM comes from the words Science, Technology, Engineering and Mathematics. Sometimes we add the letter A - Art: STEAM, not STEM. In the German language, another abbreviation is used, more precisely denoting this learning technology - MINT: M - Mathematik, I - Informatik, N - Naturwissenschaft and T - Technik. Here, as it should be, in the first place is the Queen of Sciences, mathematics, who received a second wind with the development of computer symbolic, numerical and hybrid methods for solving problems. The tandem of mathematics and computer is a powerful base for a new stage in the development of science and technology. The word mint, by the way, in English is a spicy mint herb. This educational technology is designed to refresh the somewhat stagnant air in the premises of our educational institutions.
The results of the 25-year development of this complex of training courses were displayed in more than 30 monographs, textbooks and teaching aids, on Internet sites, and in journal articles.
Monographs, textbooks and teaching aids on a set of disciplines Thermal Engineering and Thermal Power Plants were published.

Mathcad Calculation Server was created.
The articles were published in following journals:

The main features of STEM education technology:

1. Topics of previous and parallel training courses are referred to.
2. Mathematical program packages such as Maple, Mathematica, Mathcad, SMath (import substitution), etc. are used.
3. Students use the Internet, including specialized social networks.
4. Real physical experiments (engineering classes) are conducted.
5. Widespread usage of graphics and animations.
6. A huge variety of solution methods: from analytical to numerical methods.
1. Work on the topics of previous and parallel training courses: Higher mathematics / Mathematical analysis (Calculus) / Function of several variables
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\[
M := \begin{bmatrix}
X_1^2 & 2X_1Y_1 & Y_1^2 & 2X_1 & 2Y_1 \\
X_2^2 & 2X_2Y_2 & Y_2^2 & 2X_2 & 2Y_2 \\
X_3^2 & 2X_3Y_3 & Y_3^2 & 2X_3 & 2Y_3 \\
X_4^2 & 2X_4Y_4 & Y_4^2 & 2X_4 & 2Y_4 \\
X_5^2 & 2X_5Y_5 & Y_5^2 & 2X_5 & 2Y_5
\end{bmatrix}
\]

\[
a := r_1
\]

\[
v := \begin{bmatrix}
-a \\
-a \\
-a \\
-a
\end{bmatrix}
\]

\[
M \cdot \begin{bmatrix}
a_{x_2} \\
a_{xy} \\
a_{y_2} \\
a_x \\
a_y
\end{bmatrix} - v = \begin{bmatrix}
0 \\
0 \\
0 \\
0 \\
0
\end{bmatrix}
\]

\[
a_{x_2} = -0.0088705821 \frac{1}{Mm} \\
a_{xy} = -0.012100876 \frac{1}{Mm} \\
a_{y_2} = -0.0063424843 \frac{1}{Mm} \\
a_x = -0.2548647879 \\
a_y = 0.3023838928
\]
An asteroid flies past the earth!

STEM TECHNOLOGY EDUCATION: Other courses

\[
y_1(x) := \frac{a_y + \sqrt{a_y^2 + 2 \cdot a_y \cdot a_{xy} \cdot x + a_{xy}^2 \cdot x^2 - a_y \cdot a_{y2} \cdot x^2 - 2 \cdot a_x \cdot a_{y2} \cdot x - a_{y2} \cdot a + a_{xy} \cdot x}}{a_{y2}}
\]

\[
y_2(x) := \frac{a_y - \sqrt{a_y^2 + 2 \cdot a_y \cdot a_{xy} \cdot x + a_{xy}^2 \cdot x^2 - a_y \cdot a_{y2} \cdot x^2 - 2 \cdot a_x \cdot a_{y2} \cdot x - a_{y2} \cdot a + a_{xy} \cdot x}}{a_{y2}}
\]

\[x := -200 \ Mm, -199.99 \ Mm..25 \ Mm\]
2. Using not only Pascal, C, Phyton but Maple, Mathematica, Mathcad, Smath, etc.

Drawing human kidneys in Maple
3. Work with the Internet, including specialized social networks

One Chapter of a tutorial on the Mathcad user forum with color drawings, animations, files. Site visitors (students) can ask questions, comment, etc.
4. Real physical experiments in engineering classes.

Sagging Chain Experiments
Digitizing Sagging Chain
Creating a Digital twin or the sagging chain: numerical solution of a system of three transcendental equations.
Photography of Valery Ochkov’s students at the lecture "Information Technologies": young men were asked to provide data on their weight and height.
STEM TECHNOLOGY EDUCATION: Competition "Mr. 1 course ITAE"

Moscow, Russia
14-17 April, 2020

\[ \text{Вес} = a + b \cdot \text{Рост} \]

\[ a = -76.044 \, \text{kg} \]

\[ b = 0.8316 \, \frac{\text{kg}}{\text{cm}} \]
5. Widespread usage of graphics and animations

Animation of a kidney stone tomography in Mathcad
The problem of the motion of two celestial bodies has an analytical solution (ellipse-parabola-hyperbole). But this decision is difficult to master for many students. Therefore, we solved this problem numerically: we generated the X and Y vectors: the coordinates of the asteroid at five points in time of approach to Earth. The second Newton's law and the law of universal gravitation are used.
7. Humanities approach to Engineering Education

Epigraph of the article "Digital Twin of one Epidemic"

Faust
What’s that white spot on the water?

Mephistopheles
A Spanish Three-master, clearing the sound, Fully laden, Holland-bound.
There hundreds sordid souls abord her, Two monkeys, chests of gold, A lot of fine expensive chocolate, And a fashionable malady: bestowed on your kind recently.

A.S. Pushkin SCENES FROM FAUST translated by Alan Shaw
https://www.youtube.com/watch?v=q-BYkREzkk4

A part of the article "Digital Twin of one Epidemic"

Here it would be possible to choose a more scientific term. But, as we read with Chekhov in the guest’s story: “The disease is dangerous! Not only am I sick, but I can infect others as well. The disease is highly sticky!”
(http://www.gumfak.ru/otech_html/chekhov/chekhov-texts/513.shtml) (in Russian) and Chekhov was also a doctor as is well known. By the way, this story also describes the situation with quarantine, with self-isolation. The owner cannot get rid of a staying guest. He says: “My throat is terribly sore! The devil pulled me to go this morning to one friend whose child has diphtheria. I probably got infected. Yes, I feel that I got infected. I have diphtheria!” Further, the owner says—see the beginning of the footnote with the phrase about the stickiness of the disease. The guest responds to this: “I lived in typhoid hospitals—I didn’t get infected, but you’ll get infected! Hehe ... My friend, my old stump, no disease will take. Old people are tenacious." In the end, the owner escorts the guest, asking him for a loan. People stop violating quarantine, the regime of self-isolation only when the police on the street start asking them not to borrow money, though they continue to demand payments of a fine.
Conclusion

• The widespread introduction of computers in the educational process required not only to change the content and teaching methods, but also to create a new course.

• The most appropriate name for this course is Computer Engineering Calculations - CEC.

• At NRU “MPEI” this course grew out of the courses “Informatics” and “Information Technologies”, “Higher Mathematics”, “Physics”, “Chemistry”, etc.
Thank you for your attention!

Valery Ochkov
NRU "MPEI"
e-mail OchkovVF@MPEI.Ru
web-site http://twt.mpei.ac.ru/ochkov