Workshop

PUZZLE-BASED-LEARNING
An introduction to creativity, critical thinking and problem solving

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Workshop

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Part 1, Introduction

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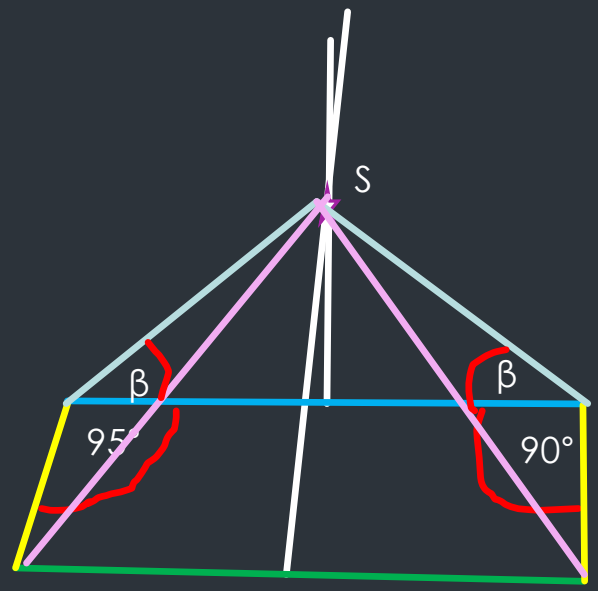
Statement: 90 = 95

Proof:



$\beta + 95 = \beta + 90$ ➡ $95 = 90$

Construction:

- Construct a four-sided figure as follows:.
- Constract the perpendicular bisector on „Green“ und „Blue“
- Connect intersection S with all verticies of four-sided figure
- Conclusion:
  - The distances - from each point of the mid-perpendicular to the vertices of the start line - have the same length.
  - The base angles β have the same size
- We get 2 congruent triangles (SSS = Turquoise– Purple - Yellow
- In congruent triangles are respective angles equal

Introduction

Five years from now, over one-third of skills (35%) that are considered important in today's workforce will have changed.

By 2025, the Fourth Industrial Revolution will have brought us advanced robotics and autonomous transport, artificial intelligence and machine learning, advanced materials, biotechnology and genomics.

World Economic Forum

Introduction

These developments will transform the way we live, and the way we work. Some jobs will disappear, others will grow and jobs that don't even exist today will become commonplace. What is certain is that the future workforce will need to align its skillset to keep pace.

A new World Economic Forum report, "The Future of Jobs", looks at the employment, skills and workforce strategy for the future.

World Economic Forum

Introduction

The report asked chief human resources and strategy officers from leading global employers what the current shifts mean, specifically for employment, skills and recruitment across industries and geographies.

World Economic Forum

Top 10 skills

in 2020

1. Complex Problem Solving
2. Critical Thinking
3. Creativity
4. People Management
5. Coordinating with Others
6. Emotional Intelligence
7. Judgment and Decision Making
8. Service Orientation
9. Negotiation
10. Cognitive Flexibility

in 2015

1. Complex Problem Solving
2. Coordinating with Others
3. People Management
4. Critical Thinking
5. Negotiation
6. Quality Control
7. Service Orientation
8. Judgment and Decision Making
9. Active Listening
10. Creativity

World Economic Forum

WORLD ECONOMIC FORUM

Top 10 skills of 2025

Type of skill

- Problem-solving
- Self-management
- Working with people
- Technology use and development

Source: Future of Jobs Report 2020, World Economic Forum.

Introduction

Solving puzzles and problems as a series of **four steps**:

1) Understanding the problem (*Recognising what is ask for*);
2) Developing a plan (*Responding to what is asked for*);
3) carrying out the plan (*Developing the result of the response*);
4) looking back (*Checking what does the result tell me*).

(Wertheimer, 1945, Polya, 1945)

Introduction

Solving puzzles and problems as a series of **six steps**:

1) understand;
2) characterise;
3) represent the problem;
4) solve the problem;
5) reflect; and
6) communicate the problem solution

(OECD, 2003:170 f.).

Introduction

Solving puzzles and problems as a series of **three steps**:

1) Understand the problem, and all the basic terms and expressions used to define it;
2) Do not rely on your intuition too much; solid calculations are fare more reliable;
3) Build a model of the problem by defining its variables, constraints, and objectives;

(Michalewicz & Michalewicz, 2012 in Puzzle-based-Learning.).

Introduction

What Are Puzzle and Problem-Solving Skills?

- Considered a transferable skill (a personal strength, as opposed to a hard skill that is learned through education or training),
- An aptitude for creative and effective problem-solving is nonetheless one of the most valued attributes employers seek in their job candidates.

Introduction

Most students – from elementary school all the way through to university education – never learn how to think about solving problems. Throughout their education, they are constrained to concentrate on specific questions at the end of chapters in a textbook. So, without much thinking, they apply the material from each chapter to solve a few problems from the end of the chapter.

Introduction

With this type of approach to “problem solving” it is not surprising that students are ill prepared for framing and addressing real-world problems. When they finally enter the real world, they suddenly find that problems do not come with instructions or textbooks.

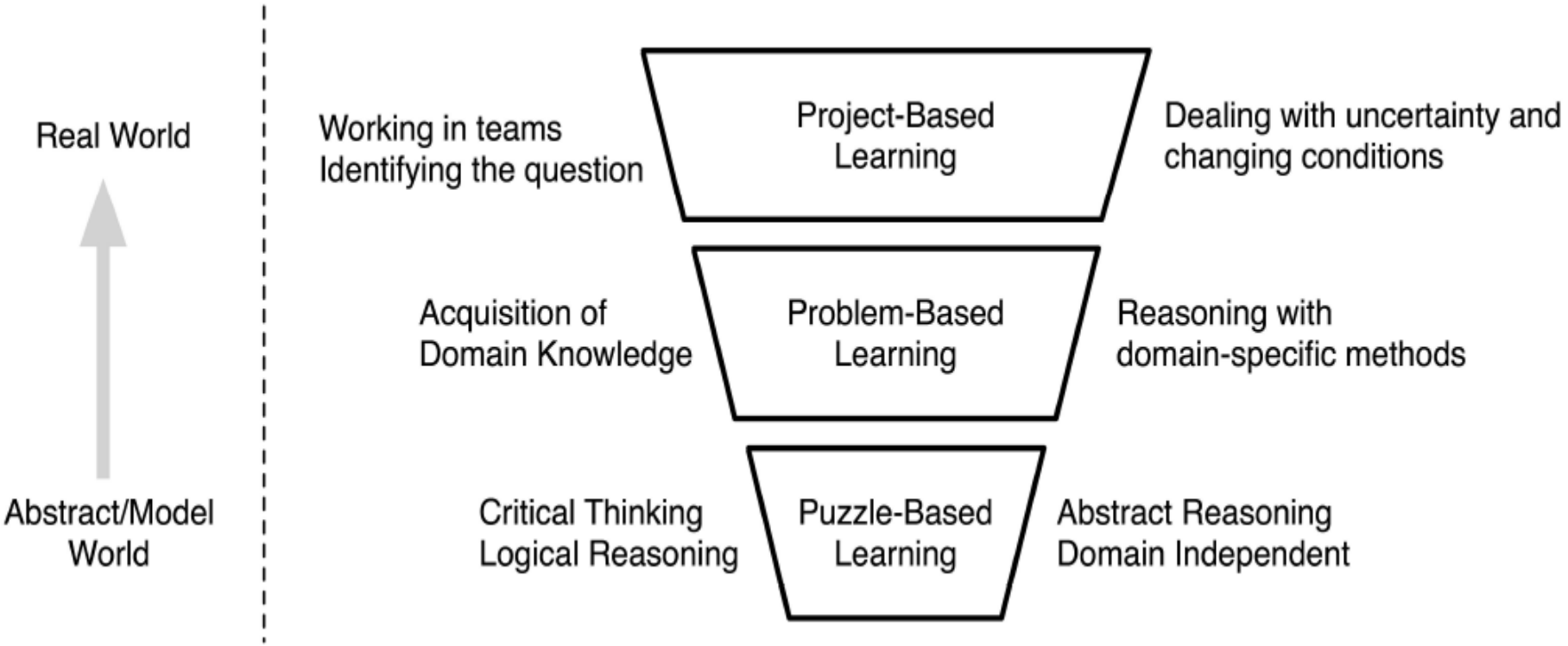
Although many educators are interested in teaching “thinking skills” rather than “teaching information and content”, the fact remains that young people often have serious difficulties in independent thinking (or problem solving skills).

Introduction

Hence, we need a different approach. Students need to ***think*** about framing and solving ***unstructured*** problems (those that are not encountered at the end of some textbook chapters…..).

My approach here in this workshop is to show how student's problem-solving skills, creativity and critical thinking can be increased by discussing a variety of ***puzzles.***

Introduction



Puzzle-Based Learning (PzBL)

- Developed by Z. Michalewicz (2008, 2014)
- Michalewicz, Z. & Michalewicz, M. (2008). *Puzzle-Based Learning: An introduction to critical thinking, mathematics, and problem solving*. Hybrid Publishers.
- Meyer, E.F., Falkner, N., Sooriamurthi, R., Michalewicz, Z. (2014). *Guide to Teaching Puzzle-Based Learning*. Springer.
- Criteria for a puzzle: independence (domain free); generality; simplicity; eureka factor; entertainment factor

Introduction

Zbigniew Michalewicz
is an entrepreneur, author and professor who is recognised internationally as a mathematical optimisation and new technologies expert.

- Michalewicz got a Master of Science degree in Applied Mathematics fromWarsaw University of Technology
- PhD and Doctor of Science in Computer Science from Polish Academy of Sciences
- In 1982, Michalewicz left Poland and moved to New Zealand (Victoria University in Wellington), later to Australia (University of Adelaide)

Video Part 1b

Introduction

Zbigniew Michalewicz
is an entrepreneur, author and professor who is recognised internationally as a mathematical optimisation and new technologies expert.

- He is the author of over two-hundred-fifty articles and twenty-five books which have been cited by over 10,000 authors.
- He is the co-founder of NuTech Solutions, SolveIT Software and Complexica where he currently serves as the Chief Scientific Officer

Video Part 2

Introduction

The first mathematical puzzles were found in **Sumerian text** that date back to around 2.500 BC ! The best evidence of the puzzle-based learning approach can be found in the works of **Aleuin, an English scholar** born around AD 732 whose main work was ***"Problems in Sharpen the Young"*** - a text which included over 50 puzzles.

Introduction

In a complementary contrast to problem-based learning, puzzles tend to be on the other end of the spectrum. They appear to be deceptively simple and usually have a single correct answer.

However, an important part of completing a puzzle is to understand what we have learned by solving a puzzle and how we can apply this knowledge to other problems.

So, puzzles are educational, but they illustrate useful (and powerful) problem-solving rules in a very *entertaining* way.

Introduction

What characterise a puzzle

- A puzzle is a non-routine, non-standard problem presented often in an entertaining way
- *Simplicity:* Easy to state and to remember and looks deceptively simple
- *Surprise:* Teases by a surprising solution and an unexpected counterintuitive answer
- *Entertainment:* Fun to solve

Edutainment = Education + Entertainment

Benefits for the Students - 1

1. **Generic:**

- Engage students' emotions, creativity and curiosity
- Enhance problem-solving, critical thinking and generic thinking skills
- Improve lateral thinking "outside the box"
- Increase motivation and the retention rate

Benefits for the Students - 2

2. Professional: illustrate many powerful problem solving principles such as:

- the invariance principle
- extreme principle
- induction principle
- pigeonhole (Dirichlet's box) principle
- start at the end
- guess and check

Benefits for the Students - 3

3. Employability: practice for job interviews

Many companies use puzzles at their job interviews to evaluate candidate's problem solving skills and select best of the best.

"Now more than ever, an education that emphasizes general problem solving skills will be important".

Bill Gates

Introduction

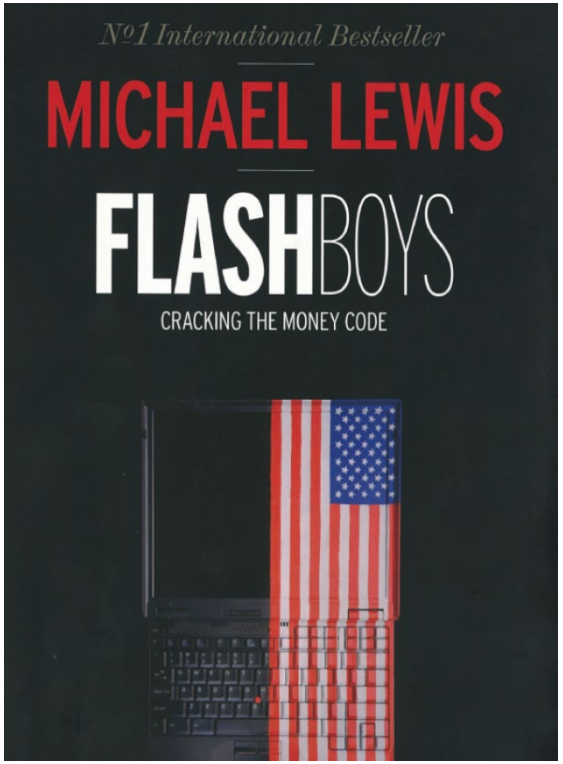
Puzzles at Job Interviews

"The goal of Microsoft's interviews is to assess a general problem-solving ability rather than a specific competence. At Microsoft, and now at many other companies, it is believed that there are parallels between the reasoning used to solve puzzles and the thought processes involved in solving real problems of innovation. You have to hire for general problem-solving capacity." (Poundstone, 2014)

Real Examples

From the book "Flash Boys" by Michael Lewis, 2014

Hiring a programmer
for a financial company
on Wall Street, New York
with the annual salary
of 270,000 USD



Real Examples: Question 1

Question 1: Is 3599 a prime number?

This is where the boring formula from algebra

$$a^2 - b^2 = (a - b) \times (a + b)$$

can help you to become rich ☺

$$3599 = (3600 - 1) = (60^2 - 1^2) = (60 - 1)\,(60 + 1) = 59 \times 61$$

Role #1

Be sure you understand the problem, and all the basic terms and expressions used to define it.

Role #2

Do not rely on your intuition to much; solid calculation are for more reliable.

Role #3

Solid calculations and reasoning are more meaningful when you **build a model** of the problem by defining its variables, constrains, and objectives.

Role #1

Be sure you understand the problem, and all the basic terms and expressions used to define it.

Video Part 3a

Role #1, illustration 1

Two groups of students are attending school. The students in group **A** boast that they are taller than the students in group **B**, while the students in group **B** enjoy the reputation of being smarter than the students in group **A.**

One day, one of the students from group **A** approached a student from group **B**, and said “We are taller than you!”. The student from group **B** thought about the statement and replied “What do you mean with that statement? Do you mean

1. Each a (group A) is taller than each b (group B)?
2. The tallest a is taller than the tallest b ?
3. Each a is taller than some b ?
4. Each b is smaller than some a ?

More ?

Role #1, illustration 1

5. Each a has corresponding b (and each of them are different one) whom he surpasses in height ?
6. Each b has corresponding a (and each of them are different one) by whom he is surpassed ?
7. The shortest b is shorter than the shortest a ?
8. The shortest a exceeds more b's than the tallest b exceeds a's ?
9. The sum of heights of the a's is greater than the sum of heights of the b's
10. The average height of the a's is greater than the average height of the b's

…..

Role #1, illustration 2

"Last afternoon was partially cloudy, yet there were many people on the street of this large city.

What means
- afternoon
- partially (cloudy)
- many (people)
- large (city)

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Role #2

Do not rely on your intuition to much; solid calculation are for more reliable.

Video 3b

Co-funded by the Erasmus+ Programme of the European Union

Role #3

Solid calculations and reasoning are more meaningful when you **build a model** of the problem by defining its variables, constrains, and objectives.

Video 3c

Role #3

Solid calculations and reasoning are more meaningful when you **build a model** of the problem by defining its variables, constrains, and objectives.

Requirements:

- It should be general enough, so that irrelevant details of the problem are hidden.
- It should be specific enough, so that we can derive a meaningful solution.

The first two rules set the groundwork for **Rule #3,** which calls for building a model of the problem.
The key question is: how can we build “efficient” models (i.e., models that are quick to build and easy to use)?
To do this, it is necessary to “investigate” the problem for special characteristics.
For example:

- Maybe the problem contains some invariants (i.e. things that do not change.
- Search for an object that could be maximized or minimized.
- Decompose the problem into smaller problems (but it requires to reassemble the smaller problem into an overall solution).

Role #1

Be sure you understand the problem, and all the basic terms and expressions used to define it.

Role #2

Do not rely on your intuition to much; solid calculation are for more reliable.

Role #3

Solid calculations and reasoning are more meaningful when you **build a model** of the problem by defining its variables, constrains, and objectives.

Video Part 3d, 6:00 min

Lecturer references

✓ For any query and request of widening

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