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DI MILANO

Computer skills advanced
Problem solving and decision making

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Outline

- Problem solving
  - Introduction
  - Simple and complex problems
  - Reasoning abilities
  - Problem solving in psychology
  - Different contexts
- Problem solving and decision making
  - Interrelations
  - Decision making techniques
- Well-conditioned problems
- The Pareto's principle

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The PROBLEM SOLVING approach (easy)

- Approach to the problem from the solution point of view (as at primary school!!!)
- to detect:

! Data at disposition

? Requirements & final objective

Data (and problem) characteristics

IT tools supporting operations needed to achieve the solution

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Problem solving: a definition

- Cross-curricular, interdisciplinary character:
- It defines way and means to solve a problem which solution is not immediate, but
  - Needing superior cognitive processes to solve real and interdisciplinary situations
  - Concerning situations which solution is not immediately evident
  - Belong to contexts going beyond a single competence, but involving more disciplines.

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Simple and complex problems

Simple problems

- Time: defined
- Aims and steps are defined in a clear way
- Few variables and simple dependencies
- A single solution or correct answer

Complex problems

- Dynamics
- Not clear definition
- Many variables or complex dependencies
- More than one solution or answer

Is it possible to transform a complex problem in a simple one?

- **YES, using the correct approach and the right means.**
- **Help from Problem Solving**

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Face a problem: from complex to simple

- From the Problem Solving point of view
  - Comprehension
  - Detection of characteristics
  - Problem representation
    - Possible subdivision in sub-problems
  - Elaboration of a solution strategy
  - Verification of the solution
  - Communication of the solution
- Each point can be supported by tools and techniques

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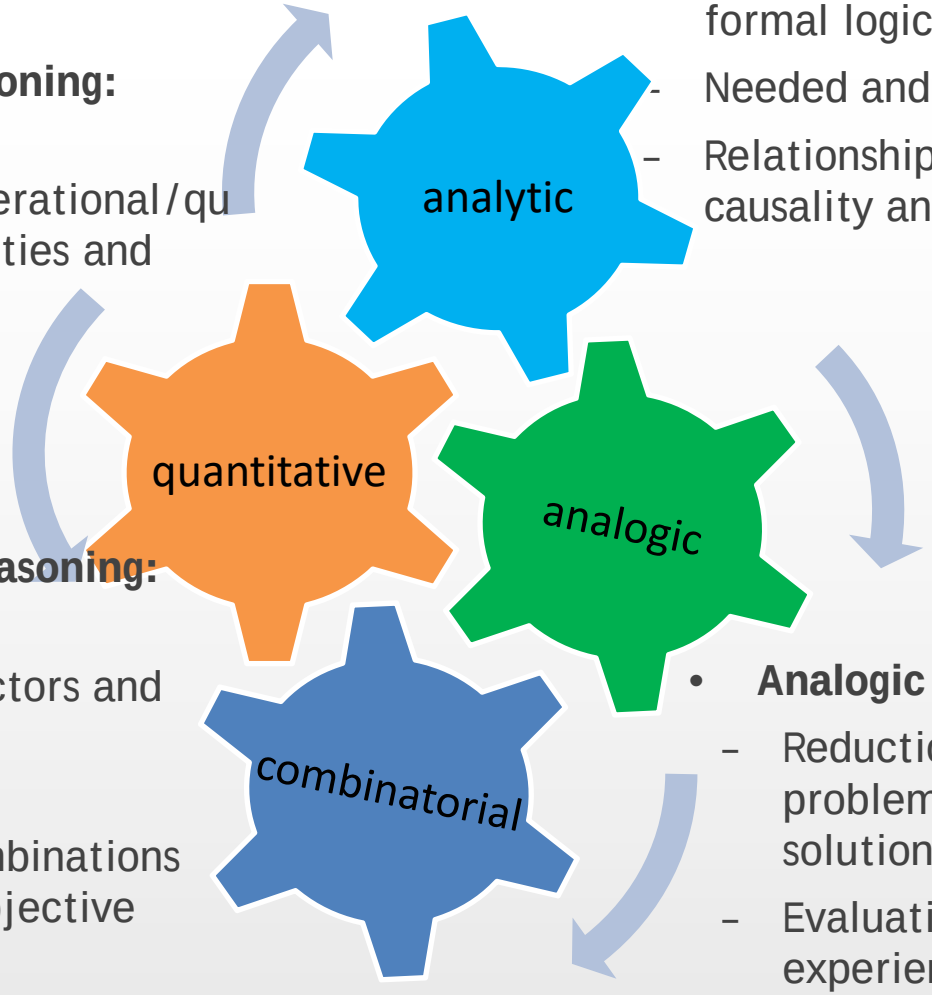
Reasoning abilities

- **Analytic Reasoning:**
  - Application of reasoning through formal logic:
  - Needed and sufficient conditions
  - Relationship between constraint causality and problem conditions

- **Quantitative reasoning:**
  - Application of mathematics/operational/quantitative properties and procedures



- **Combinatorial reasoning:**
  - Evaluation of a multiplicity of factors and of all the related combinations
  - Evaluation of combinations on the basis of objective limits
  - Selection or ordering of the possibility

- **Analogic reasoning:**
  - Reduction of known problems and related solutions
  - Evaluation of previous experiences, independently from current context

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Behaviourism and problem solving

- Problem solving as the result of beaviours learned from trial and errors or from the repetition of already known answers (Thorndike, 1930).

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Gestalt psychology and problem solving

- An individual can find the solution of a problem
  - NOT through a trial-and-error approach
  - BUT through INSIGHT

  (Köhler et al., 1935)
- **Insight**: intuition of the structure of the problem leading a restructuring to achieve the solution

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Gestalt psychology: productive problem solving

- Characterized by the presence of an insight phase of the problem structure and by its productive restructuring
- Insight is unpredictable (the moment of)

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Gestalt psychology: reproductive problem solving

- It implies the re-use of the past experience
- Sometimes it could avoid the satisfactory solution of the problem (the so-called **Functional fixedness** phenomenon)
- Functional Fixedness: inability to see the new functions of objects compared to already known ones; unability in going beyond predefined schemata, breaking a *mental set*.

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Cognitivism and problem solving

- Cognitivism proposes a vision of the world founded on the continuous feedback individual-environment
- Explicit models of external factors influence on behaviours
- Information flow, elaborated at different levels during their transition in the organism
- Solving a problem requires: understanding it, detecting the needed operations, executing them, controlling the results. If the final objective has not been achieved, then modify some steps.

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Computational approach: the space of the problem (1)

- Newell and Simon: *Problem Space* theory
  - Problems can be solved through the exploration of different paths allowing the achievement of the solution
- The *Problem Space*:
  - The set of all the possible states and all the possible paths allowing to achieve the solution. Only some of them could solve the problem.
- *The objective structure* of a problem described as a set of states:
  - *Initial state* (example: the beginning of a path);
  - *Final state (*example: the end of a path*).*
  - We need to apply some *operators*, which result is the transition from a state to the following

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Computational approach: the problem space (2)

- Newell and Simon hypothesize that people solve a problem exploring in their mind different "knowledge states": from an initial state, through a space composed of alternative states, till the final knowledge state is reached.
- Transitions from a state to the following obtained with the application of Mental Operators.
- Mental operators: coding the allowed steps and the restrictions avoiding a step in specific conditions.
- The processes act within the limits of a specific cognitive system (example: there are limitation in the working memory)

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Problem solving: heuristic methods

- Often when facing problems similar to the Hanoi Tower, people use solution strategies based on heuristic models:
  - This method implies approximated rules, not ensuring the solution of the problem (but if a solution is achieved, a person could save time and efforts)
- Newell and Simon state that the means-aims analysis is a very used heuristic method:
  - It consists at first in observing the difference between the initial state and the final objective and, after, in creating a sub-objective to reduce the difference between the two states, selecting an operator to solve this sub-task.
- The past experience often allows to detect more easily the sub-tasks.

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Problem solving: heuristic methods – expertise

- *Expertise* stand for a specific knowledge corresponding to a given domain
- An *apprentice* is who faces, for the first time, the tasks related to a specific domain.
- The chess game has been one of the first domains where the differences between experts and apprentice has been studied.
- **Initial state** of a game: the disposition of the pieces on the chessboard: 8 pawn, 2 horses, the king, the queen, the 2 towers and the 2 bishops
- **Final state**: the check-mate to the opponent

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Anderson and the ACT model

Reciprocal interconnection of 3 components:

1. Declarative memory
2. Procedural memory
3. Working memory

In this model there are 2 key-processes for the cumulative construction of the knowledge:

1. Proceduralization that is the transition from the declarative memory to the procedural memory.
2. Composition: the unnecessary rules are eliminated.

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Problem solving through analogy

- Some authors hypothesized that past experiences can't be directly applied to the current context and that in there is an indirect process, based on analogy.
- Analogic thinking: the result of a process that transfer the conceptual structure of ideas (base dominion) on another set of ideas (target dominion)
- Gick and Holyoak (1980) studied the phenomenon of the analogic transfer in problem solving application
- The participants in the study had to solve the *radiation Problem* (Duncker, 1945)

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Let's come back to our aims

After facing the problem solving and the techniques and methods by the different current psychological point of view, let us see how, practically, we could apply problem solving corresponding to the argument of this course.

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Problem solving: typologies

- Problem solving and decision making
  - When we treat a problem, how can we take the right decision?
- Algorithmic Problem solving
- Problem solving and creativity
- Problem solving and project management…
  - Computational thinking

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The decision making process

We can distinguish 5 phases:

1. Well-disposed context
2. Problem definition
3. Creation of alternatives
4. Evaluation of alternatives
5. Choice of an alternative (solution)

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Decision making: 1. well-disposed context

Creation of the context

- Right for taking efficient decisions
- Where there aren't personal interests
- Without waste of resources

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Decision making: 2. problem definition

(this is the main position of problem solving)

Definition of the problem:

- requirements, needs, objectives
- dispassion
- limits
- constraints

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Decision making: 3. creation of alternatives

Important for decision making process

- In absence of alternatives we couldn't have decisions to take!
- The alternatives are not necessarly intrinsic
  - for this reason we need to **create alternatives**
- Alternatives must be:
  - feasible
  - accurately described

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Decision making: 4. evaluation of the alternatives

The found alternatives must be evaluated considering:

- Validity
- Feasibility
- Realistic aspect
- Risks
- Potentialities
- Pro and cons
- Costs and benefits
- Financial impact
- Intangibles
- Time
- Resources

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Decision making: 5. choice of the best alternative

- The choice of the best alternative completes the cycle of the decision making process
- After this phase, we will need to practice the chosen alternative
- This phase is strongly related to the previous one
- Both the phases are linked to the problem solving process
- We can use decision making techniques

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Decision making techniques: chatchball

- From Japan
- For **group decisions**
- Aims: involved people must
  - Feel part of the decision
  - Make themselves free from prejudices or external conditioning
- Each person involved in the decision takes care of an alternative and work for its improvement
- After he/she passes the alternative to the other involved person who will improve again the alternative

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Decision making technique: delphi

- For groups
- Expert panel geographically distant
- A set of of questionnaires is sent (by mail, email or by computer systems) to a group of preselected experts
- The questionnaire is formulated to solicit and deepen individual answers to the problem
  - Experts refine the own point of view at each passage
- Usually the first questionnaire gives the problem in a general form, requiring answers and comments
  - the answers to the first questionnaire are synthesized from the research team and used to create the second questionnaire
- The second questionnaire presents the results of the first one and offers the opportunity to review the first answers following the *feedback* on the basis of the answers of the entire group
- The process is interactive and could be repeated

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Other decision making techniques

- There are other techniques, such as Brainstorming (we will see it when we will talk about the creative problem solving), SWOT for decision concerning marketing/positioning, mental maps (we will see also these last)
- Decision making techniques for individuals:
- Adaptable SWOT
- Mental map
- Pro and cons list
- F.A.R.E. (Focalizzare; Analizzare; Risolvere; Eseguire – Focus, Analyse, Resolve, Execute)

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Importance of problem solving in decision making

- Problem solving
  - at the second step of the decision making process
- If the problem is not well-conditioned, it could be difficult
  - to find the alternatives
  - To evaluate the alternatives
  - To achieve the correct solution
- It is important to define WELL the problem

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Well-defined problem

- WHY (where the exigence come from?)
- WHO does WHAT
- HOW: what resources (not only from the economic point of view)
- WHERE: is the localization important or not?
- WHEN: start, end, intermediate time
- HOW MUCH: are there economic constraints?
- CONSTRAINTS: consider all! (Ex. “Build a 100 meter high palace” is different from “build a palace”)
- Enlarged Lasswell (5 W and 1 H: Who? What? Where? When? Why? How?)

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Examples

problem CONDITIONED	problem SOLVED	Example
WELL	WELL	Sign for the exam having studied, so passing it
WELL	WRONG	Titanic
WELL	WELL	Discovery of America
WRONG	WRONG	Sign for the exam if you have not studied

Initial state, end state and operators needed to solve the problem, must be all defined in a clear way

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Pareto's principle (or "rule 80/20")

- Vilfredo, Italian economist (1848-1923)
- Studying salary distribution, noted that in a region only a few individuals (20%) own the greater part of the richness (80%).
- This fact can be synthesized in the sentence: the great part of the effect depends on a restricted number of causes
  - In general the 80% of results depends on 20% of causes.
- Different applications (from economy to daily life).

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