Universitatea Politehnica Timişoara

Programme of advanced academic doctoral studies –
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Ethics and academic integrity in scientific research and dissemination of findings

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Lectures delivered based on the materials of

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Tenure professor of transversal disciplines in the programmes of advanced academic doctoral training from 2008/2009 to 2010/2011

Course outline

1. Operating models in scientific research

2. Presentation of scientific research findings

Definitions: **model** – ♦ a representation, generally in miniature, or in a mathematical way, to show the construction, the behavior or the appearance of something; ♦ what can be used as orientation for reproductions or imitations; pattern; ♦ small scale representation of an object; scale model;

operating model = a model designed to assess the capabilities and performance of a system.

1.1. Types of models for technical systems

Physical models

- **similarity models** – the system to be modeled (actual system) and the model have similar constitutive, physical and structural elements, and similar information support in terms of aim(s), but they differ in scale;
- **analogical models -** the actual system and the model have different constitutive, physical and structural elements, but very similar information support;

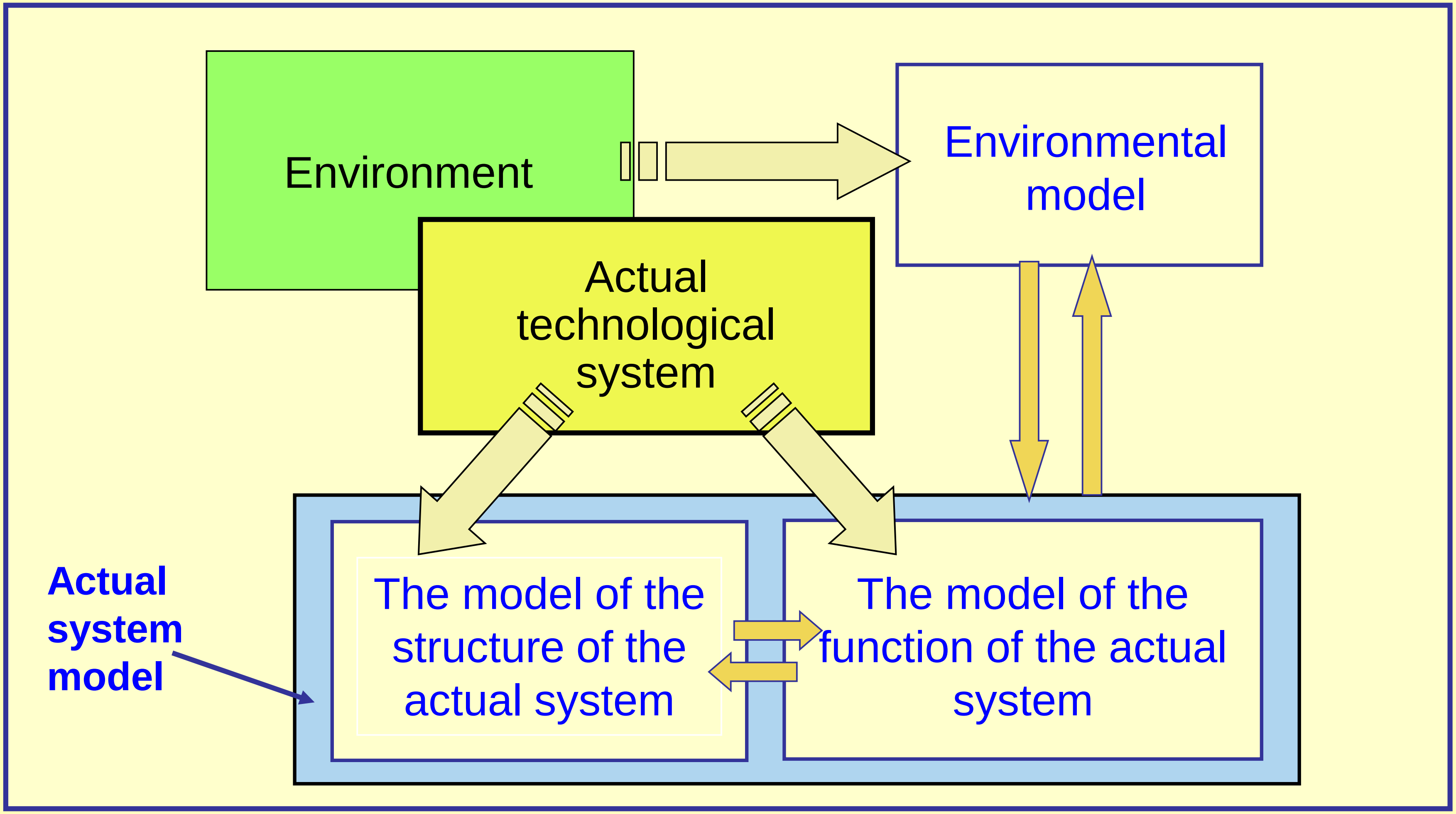
Symbolic models (iconographic or procedural) – graphic representations of the actual system, using conventional, typically standard symbols;

Logical models –– interdependent qualitative relationship between outputs (response functions) and inputs (influence factors), specific to the actual system;

Mathematical models – quantitative relations between outputs (response functions) and inputs (influence factors), specific to the actual system (with variations);

E.g. - a mathematical representation accurately describing the essential dynamic features of an entity (also called system/process).

Possible approaches in modelling an actual system



1.2. Theoretical approaches

Mathematical modelling in engineering

- ❖ the result of an iterative, abstract and idealized descriptive process;
- ❖ grounded in scientific investigation,

  of an actual system / process,

  using efficient mathematical and/or IT language,

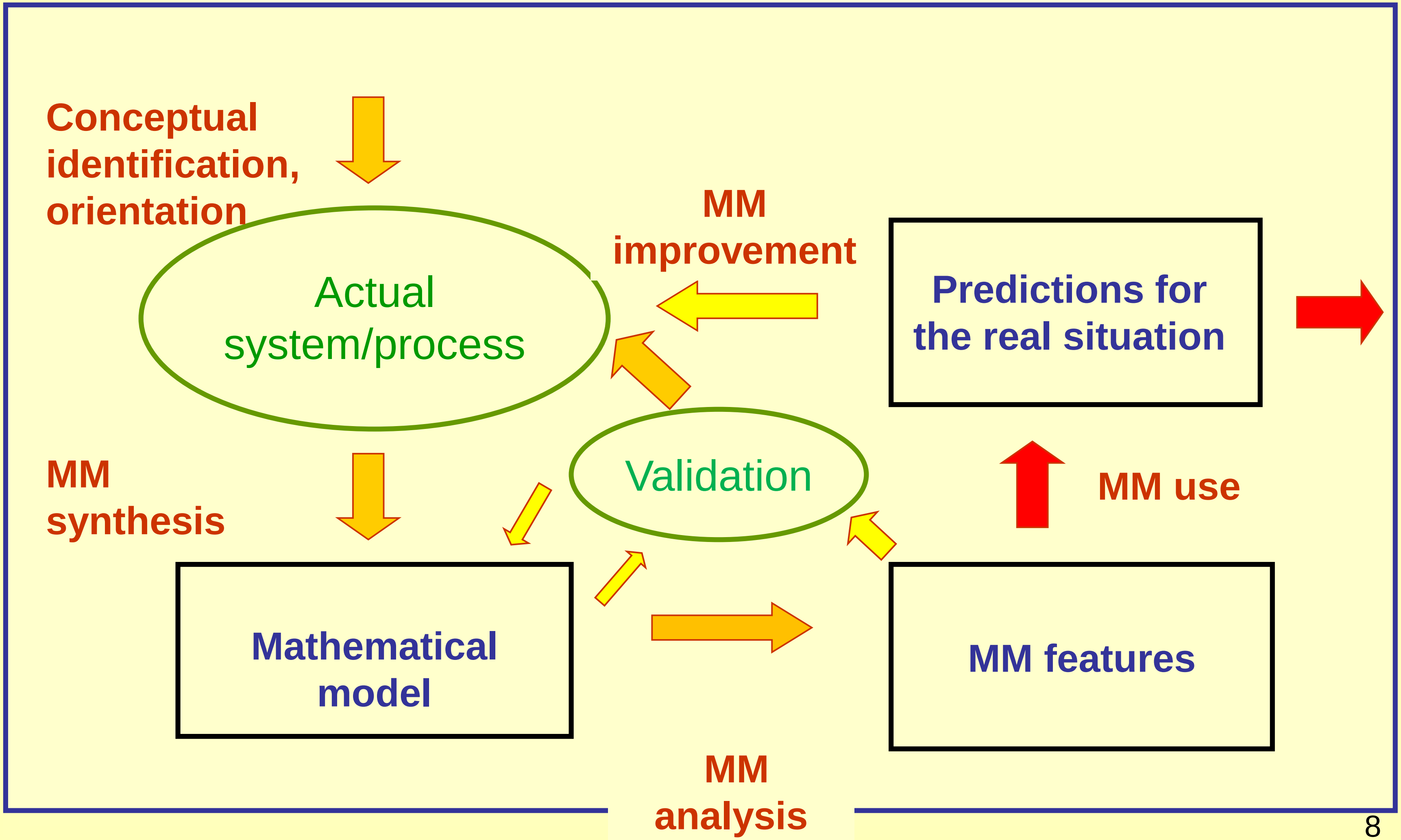
- ❖ proper for future practical applications, in accordance with scientific research objectives, such as: knowledge, simulation, optimization, and management or design of the system / process under investigation.

***Iteration** = repetition of a certain calculation method, by its application to the result arrived at in the previous calculation stage.*

Operational models in scientific research

- Mathematical modelling is not a purpose in itself, but a method and an instrument of representation and knowledge of reality, proper to the scientific researcher's interests.
- Depending on the objectives and limitations applied to modelling, a given real entity may be described by an array of mathematical models.
- In terms of complexity and dynamics of the research object, mathematical models may refer to its essential structural/functional components, or to the research object as a whole.
- According to the nature of the research object and to the researcher's interests and resources, the mathematical models used may be:
  - acquired through theory (starting from conceptual models) or empirically (of the black-box type);
  - rendered in parametric or nonparametric form, graphic or numerical.

Significant stages of MM development and use



Conceptual identification, orientation

- establishing independent variables (inputs) and dependent variables (outputs) – orientation;
- making logical and empirical correlations between inputs (influence factors) and outputs (response factors).

Mathematical model synthesis

- establishing modelling, simplification and customizing hypotheses;
- deciding on MM form: algebraic equations, differentials, integrals, etc., inequalities, functions and operators, graphic representations specific to the investigated actual system / process, tabular functions (they render mass/energy balances, cases of dynamic equilibrium, causality relations, etc.);
- parameter determination for the established MM form.

Validation

- model evaluation in standard scenarios for which there is empirical data, using performance criteria and indicators, as well as objectively proper functions for the object of research and the adopted MM.

MM analysis

- delimiting MM features;
- establishing validity limits (conformation to restrictions and limitations of applicability in the real world) and manner of use;
- establishing the implementation method.

MM usage

- MM usage for predictions of an actual system / process behaviour, by making use of the solutions provided by the MM for different scenarios.

MM improvement

- MM adjustment to new situations according to the predictions obtained and to their testing in practice;
- MM improvement with new capabilities through extension and aggregation.

AGGREGATE *(Tehn.) = to adhere, to reunite, to combine.*

Mathematical models for technological systems

- deterministic *models*

- probilistic *models*

- vague *models* (fuzzy)

Vague *adj.* ***1.*** *Which is not clearly explained; unclear, indefinite, undetermined.*
2. *Uncertain, imprecise. 3. Which cannot be well analyzed.*

1.3. Empirical approaches

Modern technological systems – characteristics:

- complex (large number of influence factors of different physical and chemical nature)

- dynamic (variability in time of states and interactions, based on on inertial behaviour)

- poorly organized (behaviour characterised by probabilistically conditioned performance)

- diffuse (strong interactions among influence factors, which influence the accuracy of the transformations performed)

The general effectiveness of analytical modelling decreases as the above mentioned characteristics (of actual systems/processes) are emphasized, while that of empirical modelling and of numerical modelling increase.

Theory versus experiment

- The usefulness of analytical models (based on the customization of physical and chemical laws, etc.) is mainly gnoseological, and their application to solving practical problems is difficult, implying a lot of hard work.
- Empirical modelling deliberately ignores the analysis of phenomena and interactions within the actual system/process; the gnoseological usefulness of the models is inevitably limited (black-box type models).
- Empirical models are determined by algorithm and statistical methods based on simplicity, efficiency and confidence.
- The validity of the results provided by empirical models is strictly located and difficult to be extrapolated out of field under investigation.

Gnoseology – Branch of philosophy that studies man's possibility of knowledge of the world*, as well as the laws, sources and forms of this knowledge; theory of knowledge. [cf. gr. gnosis – knowledge, logos – science]****.***

Empirical research programmes

Experiment – an investigation process carried out by controlled intervention in the functioning and development of an actual system.

Experiment structure – number, sequencing and conditions of development of test trials:

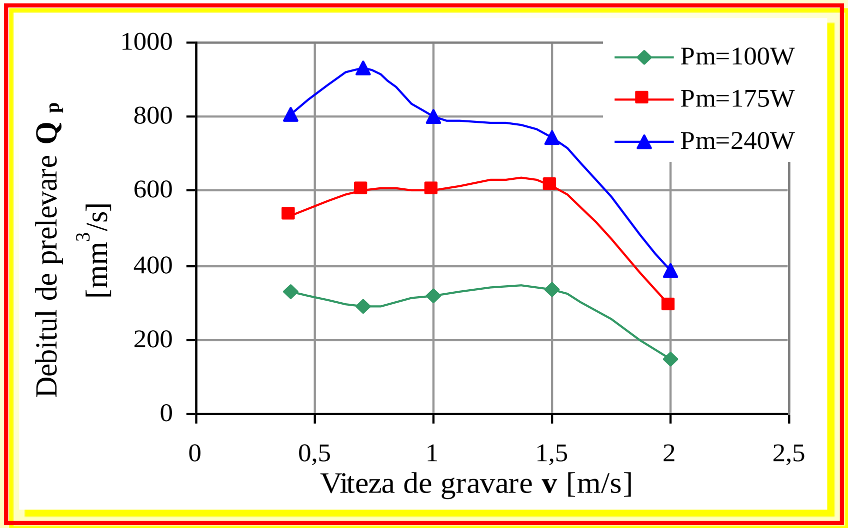
- a given set of values of controllable factors defines one state of the research object and, implicitly, one trial test;
- within one trial test, each influence factor may take one and only one of the allowed values;
- the set of combinations of influence factor values determines the magnitude (the number of trial tests) of the experiment (sometimes).

The Gauss – Seidel strategy (classic experiment)

- empirical research is treated as a one factor experiment = at a given moment, only one factor is modified, the remaining controllable factors being maintained at constant values;
- to mark out the action of a factor, only some of the performed trial tests are used, which increases the experiment volume and cost

Slogan:

"one factor at one given moment"



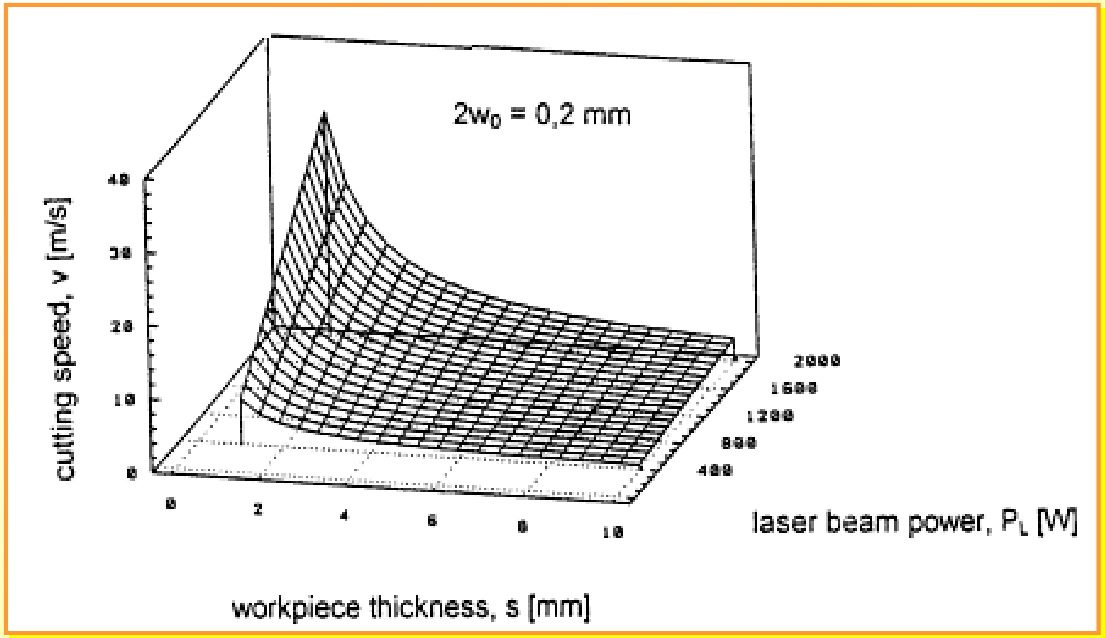
The Box-Wilson strategy (factorial experiment)

- the value of all existing factors changes with each trial test;
- the action of each factor is manifest in all trial tests;
- the volume of the experiment decreases significantly with increased confidence in the results.

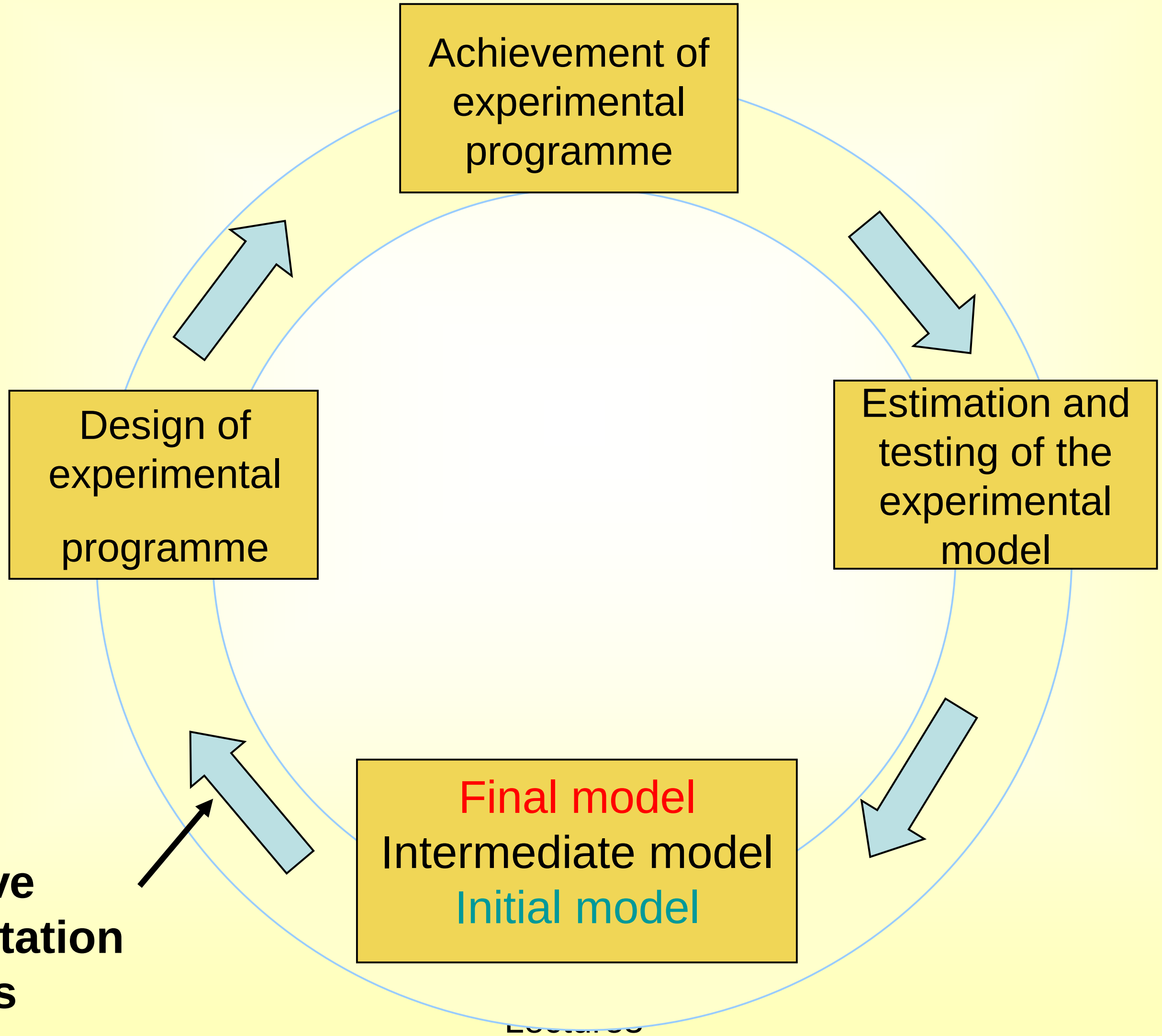
Slogan:

"all factors each and every moment"

In statistics, a full **factorial experiment** is an experiment whose design consists of two or more factors, each with discrete possible values or "levels", and whose experimental units take on all possible combinations of these levels across all such factors.
http://en.wikipedia.org/wiki/Factorial_experiment



Cycles of factorial experimentation



Iterative experimentation cycles

2.1. Scientific papers

Scientific paper (broad meaning) – any written paper, usually presented publicly, which can be characterized as showing scientific originality in terms of design, method of investigation, structure and/or content;

Scientific paper (narrow meaning) / Scientific article - written, synthetic presentation of original theoretical and/or empirical research findings, published in monographic scientific journals or specialised books.

Monograph – *Ample scientific study on a certain topic, developed minutely and multilaterally. (fr. Monographie****).***

The originality of scientific papers is given by the presentation of new information and knowledge, and/or by a novel interpretation of existing information and knowledge.

2.2. Content and characteristics of scientific papers

- According to purpose
  - bibliographic synthesis papers,
  - mainly theoretical and/or phenomenological papers,
  - mainly empirical papers.

- Characteristics:
  - descriptive character,
  - comparative character,
  - interpretative character.

2.3 Means of communication and presentation used in a scientific paper:

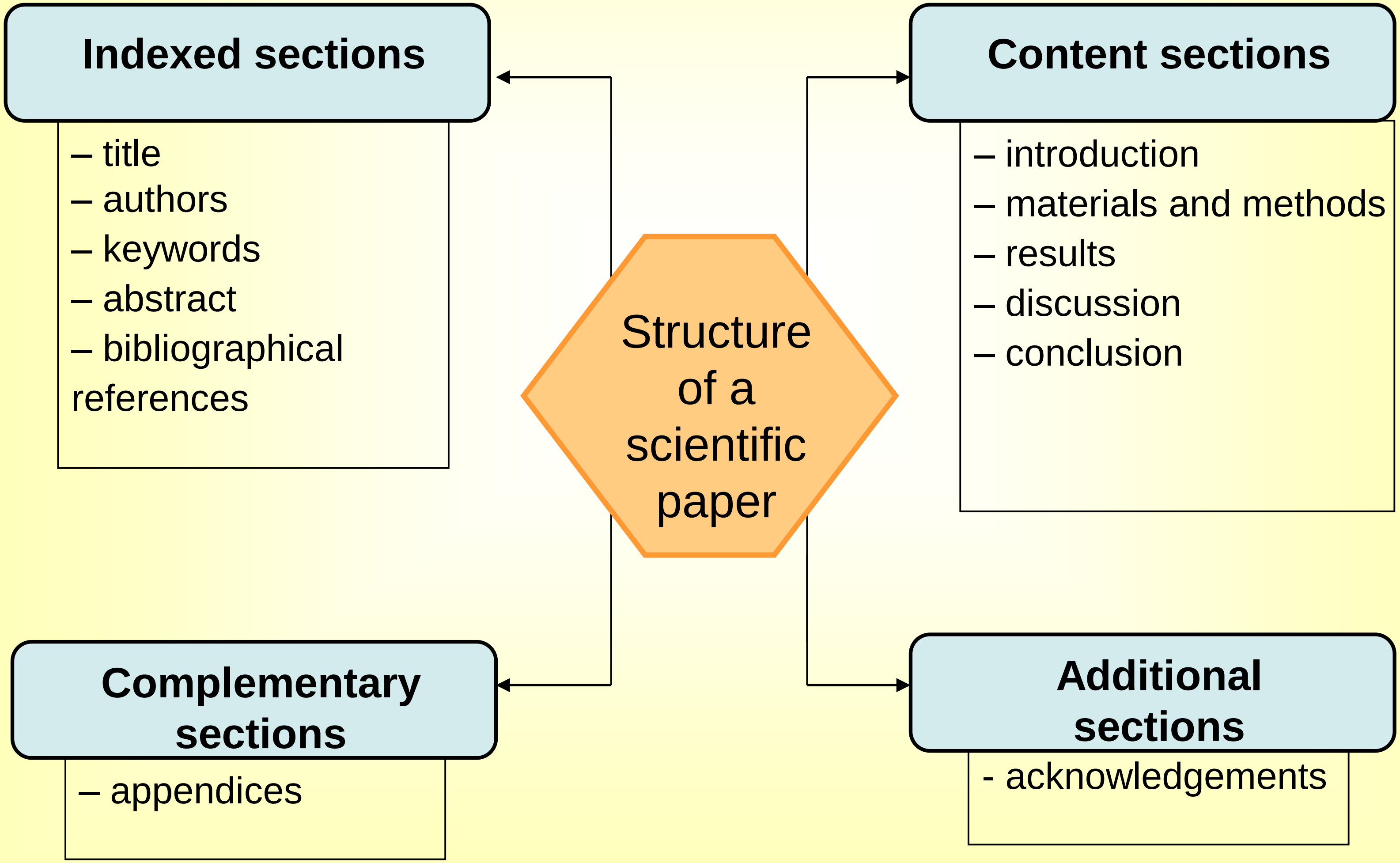
- text – the main alternative, often simple and accessible, to highlight the content of a scientific paper;

- mathematical relations – specific to papers based on mathematical proof and quantitative correlations, expressed by analytical, empirical or numerical functions;

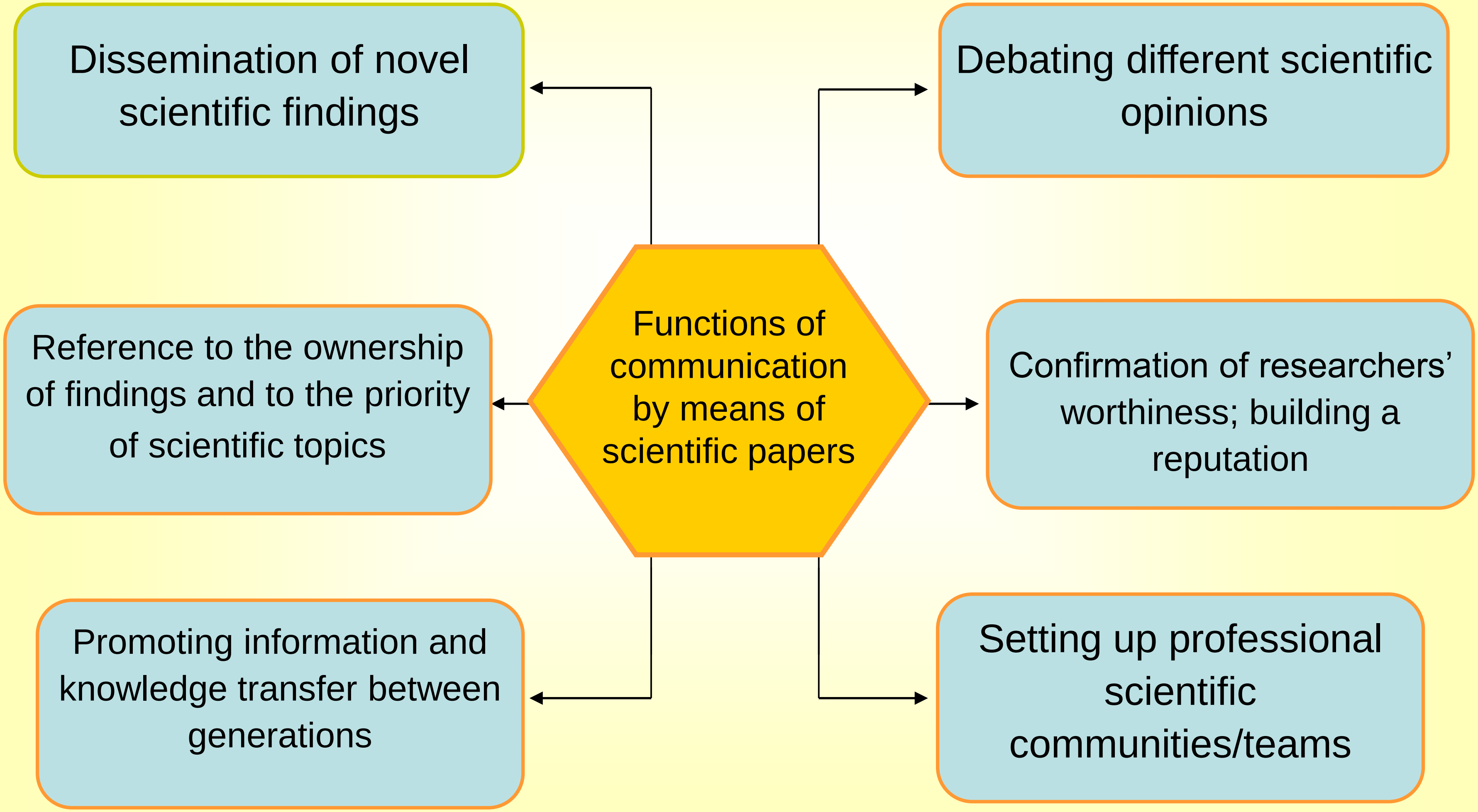
- tables – priority alternative, sometimes the only possible one, for the logical organization and synthetic presentation of a large set of precise, repetitive numerical data;

- figures (graphs, diagrams, organigrams, drawings, photos, etc.) – the most appropriate alternative for the synthetic, intuitive presentation of the current state, of interactions, tendencies and developments.

2.4. The structure of scientific papers



2.5. Functions of communication by means of scientific papers



2.6. Communication channels in scientific papers

Informal communication channels (e.g. casual or scheduled personal contacts among researchers), which allow for total freedom in terms of the structure and transmission of messages containing information and knowledge of mutual interest

Informal action – *action that develops outside formal, official (institutional) constraints; unofficial, informal, familiar. (*From Engl. **informal***)*

Formal communication channels (e.g. research and development projects, scientific events, scientific journals, specialised books, bibliographical databases, etc.), which confine the extent, structure and presentation form of the same messages

Formal and informal communication channels are complementary, informal communication becoming more and more important and popular

2.7. Types of scientific papers

- ► funding requests/applications for research and development projects
- ► scientific research and R&D reports
- ► master dissertations and doctoral theses
- ► scientific papers
- ► scientific books
- ► (filing an application for) innovation patents
- ► IT products with bibliographical purposes (contents, abstracts, scientific citation indices, innovation patent citation indices, etc.)

2.8. Scientific papers published in scientific journals

► **A**nalysis scientific papers

- Notes / research reports (2 to 4 pages)
- Creative and interpretative analysis scientific papers (8 to 10 pages)
- Editors' letters
- Essays

Essay – *A short and original study on philosophical, literary or scientific topics, without exhaustiveness claims.*

► Synthesis scientific papers

- Critical and creative bibliographical synthesis scientific papers (10 to 20 pages)
- Report papers on the researches conducted and the findings arrived at by a research team/laboratory

2.9. Scientific and professional books

- ► **A**nalysis and/or synthesis publications
  - Monographs
  - Specialised books
- ► Informative and reference publications
  - Encyclopaedias, lexicons, dictionaries
  - Guides, handbooks
  - Directories
- ► Academic publications
  - Courses, textbooks, treaties

2.10. Factors involved in scientific communication

- Researchers - authors – performers of scientific research and writers of related scientific papers
- Editors – individuals and/or legal bodies that manage evaluation and publishing activities
- Expert-reviewers – independent experts able and willing to assess the quality and originality of scientific papers
- Funders- individuals and/or legal bodies that provide financial support to scientific research projects
- Readers – the target audience of scientific papers.

Comment

As far as doctoral students are concerned, the main carriers of novel scientific information are:

- scientific research reports,

  in particular, PhD theses and

- original scientific papers,

  published: in scientific journals or conference proceedings.