Data Mining Tools in Science Education

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ABSTRACT

The main principle of paper is Data Mining in Science Education (DMSE) as Problem Solving. The main goal of paper is consisting in Delimitation of Complex Data Mining Tool and Partial Data Mining Tool of DMSE. The procedure of paper is consisting of Data Preprocessing in Science Education, Data Processing in Science Education, Description of Curricular Process as Complex Data Mining Tool (CP-DMSE), Description of Analytical Synthetic Modeling as Partial Data Mining Tool (ASM-DMSE) and finally Application of CPDMSE and ASM-DMSE via Physics Education.

Keywords: Data Mining in Science Education, Complex Data Mining Tool – Curricular Process, Partial Data Mining Tool – Analytical Synthetic Modeling, Visualia - Result of Visualization.

1. INTRODUCTION

An imperative of data mining and a need of cooperation of the human with today´s computers are emphasized by D.A.Keim (see [1] - Zaskodny, Pavlat, 2009-2010, [2] -Keim, 2002):

“The progress made in hardware technology allows today´s computer systems to store very large amounts of data. Researchers from the University of Berkeley estimate that every year 1 Exabyte (= 1 Million Terabyte) of data are generated, of which a large portion is available in digital form. This means that in the next three years more data will be generated than in all of human history before”.

“If the data is presented textually, the amount of data which can be displayed is in range one hundred data items, but this is like a drop in the ocean when dealing with data sets containing millions of data items”.

“For data mining to be effective, it is important to include the human in the data exploration process and combine the flexibility, creativity, and general knowledge of the human with the enormous storage capacity and the computational power of today´s computers.”

Modeling as a partial tool of data mining – quotation acoording to J.K.Gilbert ([3] - Gilbert, 2008)**:**

“In a nightmare world, we would perceive the world around us being continuous and without structure. However, our survival as a species has been possible because we have evolved the ability do “cut up” that world mentally into chunks about which we can think and hence give meaning to”.

“This process of chunking, a part of all cognition, is modeling and the products of the mental actions that have taken place are models. Science, being concerned with the provision of explanations about the natural world, places an especial reliance on the generation and testing of models”.

2. DATA MINING

Data Mining - analytical synthetic way of extraction of hidden and potencially useful information from large data files (continuum data-information-knowledge, knowledge discovery)

Data Mining Techniques - the system functions of structure of formerly hidden relations and patterns (e.g. classification, association, clustering, prediction)

Data Mining Tool - a concrete procedure how to reach the intended system functions

Complex Tool - a resolution of complex problem of relevant science branch

Partial Tool - a resolution of partial problem of relevant science branch

Result of Data Mining - a result of data mining tool application

Representation of Data Mining Result - a description of this what is expressed

Visualization of Data Mining Result - optical retrieval of data mining result

Data Mining Cycle - Data Definition, Data Gathering, Data Preprocessing, Data Processing, Discovering Knowledge or Patterns, Representation and Visualization of Results.

See [4], [5], [6], [7], [8], [9] (P.Tarabek, P.Zaskodny, V.Pavlat, P.Prochazka, V.Novak, J.Skrabankova, 2009- 2010).

Quoted sources in [4], [5], [6], [7], [8], [9]:
E.g. American Library Association, M.C.Borba, E.M.Villarreal, G.M.Bowen, W-M Roth, C.Brunk, J.Kelly, R.Kohavi, Mineset, B.V.Carolan, G.Natriello, N.Delavari, M.R.Beikzadeh, S.Phon-Amnuaisuk, U-D Ehlers, J.M.Pawlowski, U.M.Fayyad, G.Piatelsky-Shapiro, P.Smyth, J.Fox, D.Gabel, J.K.Gilbert, O.de Jong, R.Justi, D.F.Treagust, J.H.Van Driel, M.Reiner, M.Nakhleh, W.Hämäläinen, T.H.Laine, E.Sutinen, M.Hesse, A.H.Johnstone, M.J.Kearns, U.V.Vazivani, D.A.Keim, R.Kwan, R.Fox, FT Chan, P.Tsang,

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3. DATA PREPROCESSING IN SCIENCE EDUCATION

Result of Data Preprocessing – Educational Communication of Natural Science as a succession of transformations of education content forms:

• **The transformation T1** is transformation of scientific system of natural science to communicable scientific system of natural science (the first form of education content existence),

• **The transformation T2** is transformation of communicable scientific system of natural science to educational system of natural science (the second form of education content existence),

• **The transformation T3** is transformation of educational system of natural science to both instructional project of natural science and preparedness of educator to education (the third and fourth forms of education content existence),

• **The transformation T4** is transformation of both instructional project of natural science and preparedness of educator to results of education (the fifth form of education content existence),

• **The transformation T5** is transformation of results of natural science education to applicable results of natural science education (the sixth form of education content existence)

See [10] (Brockmeyer, 1982), [11], [12], [13] (Tarabek, Zaskodny, 2007-2008), [14] (Tarabek, Zaskodny, 2008-2009), [15], [16] (Zaskodny, 2006, 2009).

4. DATA PROCESSING IN SCIENCE EDUCATION

Result of Data Processing – Curricular Process of Natural Science as a succession of transformations of agorithmized and formalized education content forms:

i. The form of education content existence - "**variant form of curriculum**"

ii. The curriculum - "**education content**" (see [17]-Prucha, 2005)

iii. The variant forms of curriculum have got the universal structure (four structural elements - sense and interpretation, set of objectives, conceptual knowledge system, factor of following transformation)

iv. The variant forms of curriculum were selected on the basis of fusion of Anglo-American curricular tradition and European didactic tradition

v. The curricular process is defined as the succession of transformations T1-T5 **of curriculum variant forms:**

"**conceptual curriculum**" (output of T1, the first variant form of curriculum) - the communicable scientific systém

"**intended curriculum**" (output of T2, the second variant form of curriculum) - the educational system of natural science

"**projected curriculum**" (output of T3, the third variant form of curriculum) - the instructional project of natural science

"**implemented curriculum-1**" (output of T3, the fourth variant form of curriculum) - the preparedness of educator to education

"**implemented curriculum-2**" (output of T4, the fifth variant form of curriculum) – the results of education

"**attained curriculum**" (output of T5, the sixth variant form of curriculum) - applicable results of education

See [6] (Prochazka, Zaskodny, 2009-2010).
Quoted sources in [6]:
E.g. A.V.Kelly, M.K.Smith, W.Doyle, M.Pasch, A.M.Sochor, V.V.Krajevskij, I.J.Lerner, J.McVittie, K.Carter, G.M.Blenkin, L.Stenhouse, E.Newman, G.Ingram, F.Bobitt, R.W.Tyler, H.Taba, C.Cornblet, S.Grundy, D.Lawton, P.Gordon, M.Certon, M.Gayle, G.J.Posner

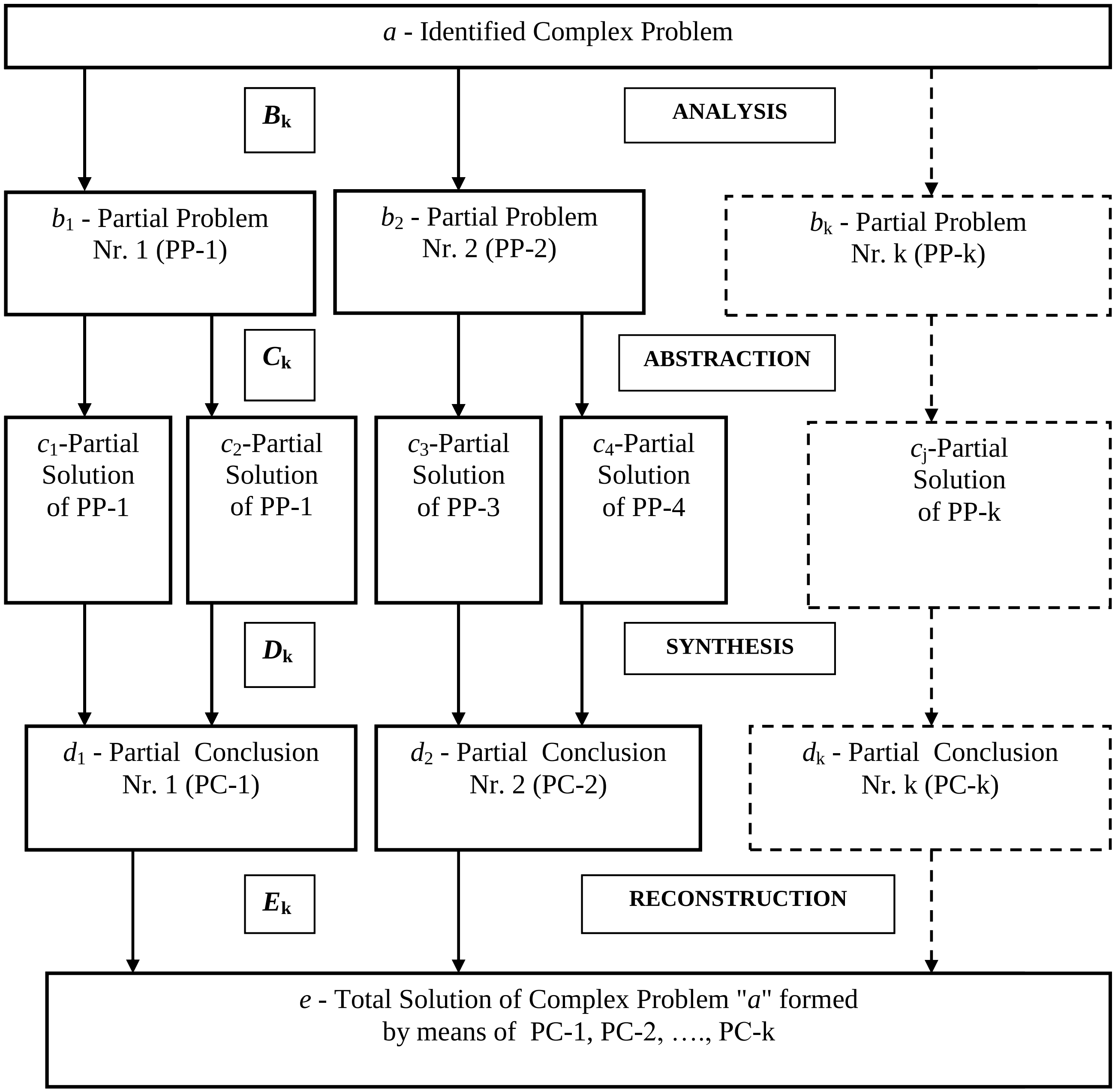
5. COMPLEX AND PARTIAL TOOL OF DMSE: CP-DMSE, ASM-DMSE

Complex tool of DMSE is given by curricular process of natural science (CP-DMSE). CP-DMSE delimits the correct education content via succession of transformations T1-T5.

Partial tool of DMSE is given by analytical synthetic modeling (ASM-DMSE). ASM-DMSE describes the mediated or real problem solving within the inputs and outputs of individual transformations T1-T5. In this paper, the description of ASM-DMSE is realized by means of both visualia Vis.1 and Legend to Vis.1.

Legend toVis.1

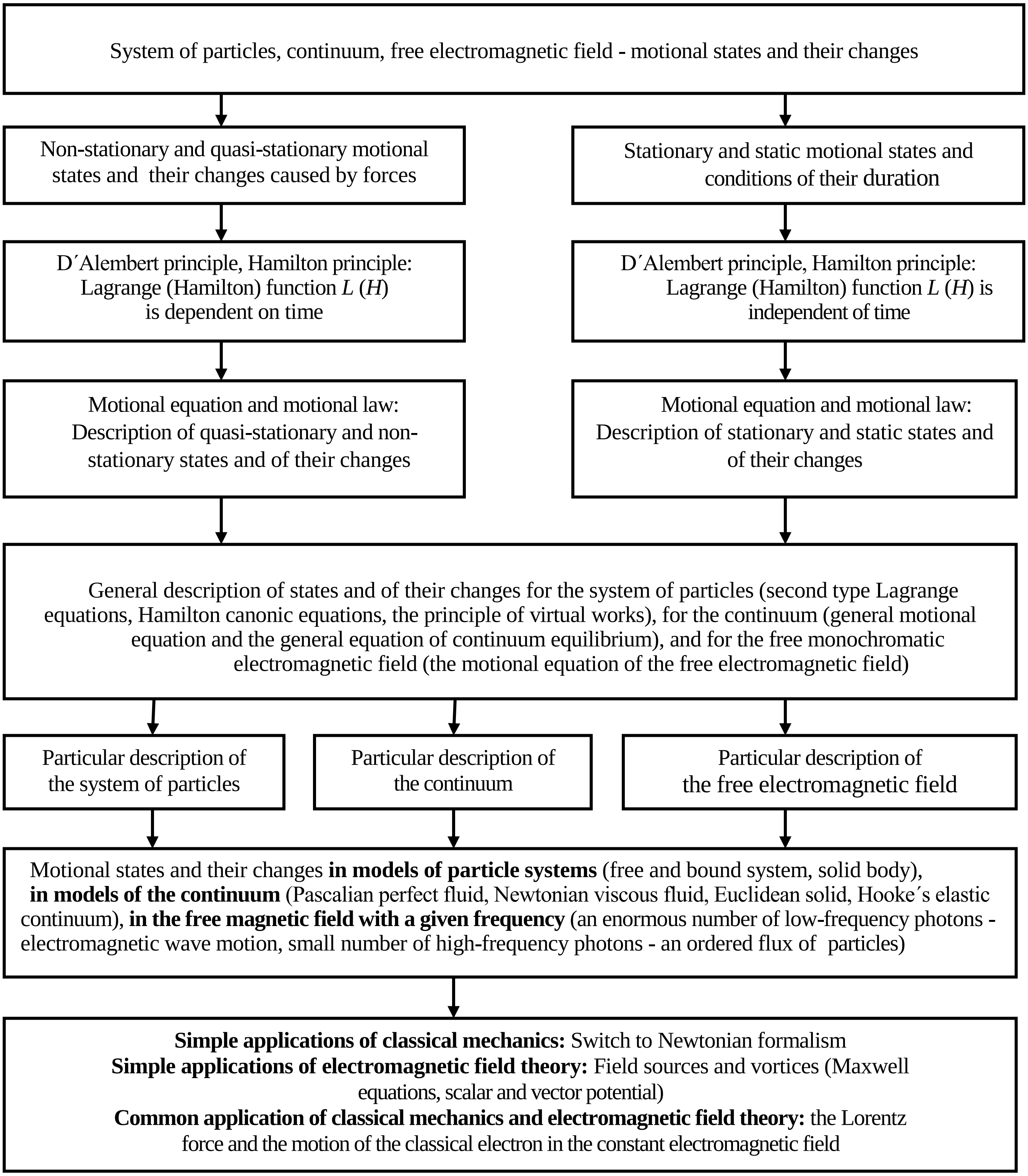
a (Identified Complex Problem) –Investigated area of reality, investigated phenomenon
$\boldsymbol{B_k}$ (Analysis) – Analytical segmentation of complex problem to partial problems
$\mathbf{b_k}$ (Partial problems PP-k) – Result of analysis: essential attributes and features of investigated phenomenon
$\boldsymbol{C_k}$ (Abstraction) – Delimitation of partial problems essences by abstraction with goal to acquire the partial solutions
$\boldsymbol{c_k}$ (Partial solutions PS-k) – Result of abstraction: partial concepts, partial pieces of knowledge, various relations, etc.
$\boldsymbol{D_k}$ (Synthesis) – Synthetic finding dependences among results of abstraction
$\boldsymbol{d_k}$ (Partial conclusions PC-k) – Result of synthesis: principle, law, dependence, continuity
$\boldsymbol{E_k}$ (Intellectual reconstruction) – Intellectual reconstruction of investigated phenomenon /investigated area of reality
e (Total solution of complex problem "*a*") – Result of intellectual reconstruction: analytical synthetic structure of final knowledge (conceptual knowledge system)



Vis. 1
General model of analytical-synthetic structure

6. APLICATION OF PARTIAL TOOL ASM-DMSE

The application of ASM-DMSE is the visualia Vis.2 from the area of physics education. The visualia Vis.2 is analytical synthetic model of classical non-statistical physics (classical mechanics, mechanics of continuum, free electromagnetic field). This visualia constitutes a part of physics conceptual curriculum as a part of communicable scientific system of physics (a part of output of transformation T1).



Vis 2:
An analytical synthetic model of classical non-statistical physics
(a part of conceptual curriculum of physics - a part of communicable scientific system of physics – output of transformation T1)

The visualized result Vis.2 of data mining in physics education constitutes the paramorphic model and hypertextual representation, represents the external conceptual knowledge systems as external representation of general social experience.

The visualized result also represents the concrete type of data file - the representation of classical mechanics, mechanics of continuum and free electromagnetic field.

Remarks:

The visualization of all conceptual curriculum of physics (classical, quantum and relativistic statistical and non-statistical physics) - **see English book** [15] P.Zaskodny (2006): Survey of Principles of Theoretical Physics.

The visualization of curricular process of physics - **see Czech book** [16] P.Zaskodny (2009): Curricular Process of Physics.

The variant form of curriculum - **see Czech book** [17] J.Prucha (2005): Modern Educational Science.

7. CONCLUSION

The results of paper:

1. Educational Communication of Natural Science as Result of Data Preprocessing

2. Educational Communication of Natural Science as Five Transformations T1-T5 of Knowledge from Natural Science to Mind of Educant

3. Curricular Process of Natural Science as Result of Data Processing

4. Curricular Process of Natural Science as Structuralization, Algorithm Development and Formalization of Educational Communication of Natural Science

5. Curricular Process as Succession of Five Transformations T1-T5 of Curriculum Variant Forms

6. Curriculum Variant Forms as Forms of Education Content existence

7, Formalization of Curriculum Variant Form (Four of Universal Structural Elements: Sense and Interpretation, Set of Objectives, Conceptual Knowledge System, Factor of Following Transformation)

8. Variant Forms of Curriculum:

Conceptual Curriculum as Communicable System of Natural Science

Intended Curriculum as Educational System of Natural Science

Projected Curriculum as Instructional Project of Natuaral Science and Its Textbook

Implemented Curriculm-1 as Preparedness of Educator to Education

Implemented Curriculum-2 as Results of Education in Mind of Educant

Attained Curriculum as Applicable Results of Education

9. Curricular Process as CP-DMSE (Structuralization, Algorithm Development and Formalization of Five Transformations Succession T1-T5)

10. Analytical Synthetic Modelling as ASM-DMSE (Modelling Inputs and Outputs of Transformations T1-T5)

11. Analytical Synthetic Models as Results of Problems Solving (Real or Mediated Problems)

12. Application of CP-DMSE and ASM-DMSE via Physics Education (Visualia of Conceptual Curriculum in Area of Classical Non-Statistical Physics, Need of Visualiae of All Curriculum Variant Forms as Application of CP-DMSE)

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