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An Ontology-based Framework for Organizing Research Support Contents in E-Learning Environment

Maryam Tayefeh Mahmoudi[1,2]
[1]School of Electrical and Computer Eng., College of Eng., University of Tehran,
[2] Knowledge Management & E-Organizations Group, IT Research Faculty, Research Institute for ICT
Tehran, Iran
mahmodi@itrc.ac.ir

Fattaneh Taghiyareh
School of Electrical and Computer Eng., College of Eng.
University of Tehran
Tehran, Iran
ftaghiyar@ut.ac.ir

Babak Nadjar Araabi
School of Electrical and Computer Eng., College of Eng., University of Tehran
Tehran, Iran
araabi@ut.ac.ir

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Abstract— **Transferring information in an organized and coordinated way is an effective factor in forming innovative mentality in learner. Content organization has a significant role on this mentality formation. The objective of content organization may be representing a description, analyzing a subject, presenting a justification, applying a reasoning style and consolidating a situation. The purpose of this study is to present a framework for organizing research support content, considering the projection of learner's reasoning style, content processing perspective, and existing features of content, onto research abilities. Applying these different orthogonal aspects may bring about a precise research ability. In order to provide an efficient research support e-learning environment, it is necessary to enrich a traditional education system with research support services. Such an enriched environment affects mental/practical ability of researcher as well as accelerating research process through decreasing time, cost and energy.**

Keywords- Content organization; intelligent content organization; e-learning, research support content; research ability improvement.

I. INTRODUCTION

Content has a significant role to navigate the learner's mental model in research and educational environment with both traditional and web-based forms [1]. The structure of the existing contents usually available to the learners can only raise their knowledge level, but it does not aim to improve their research abilities [2]. To overcome this problem, certain features should be considered in content that may lead to formation of certain research abilities in learner.

It is obvious that, features in learning contents (either with electronic or non-electronic formats) should be devised in such a way that yield an appropriate realm for audiences to select proper frameworks for research thinking at different levels. To implement such a system, learner's model and his/her research style have significant role in determining his/her certain research abilities. E-learning systems equipped with research support tools may provide an appropriate environment to generate research support contents in online form [3]. Regarding this, in this paper, we propose a framework

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for organizing research support contents and its necessities in e-learning environment. In this respect, a projection should be considered from the set of the existing research abilities onto the required content features, content organization perspectives and reasoning style of learner.

In our framework, we focus on text as a popular type of content, and by content features we therefore mean the features which are to be observed in a text to provide the desired research abilities. Due to this reason, we call this kind of content research support content, which can have impacts on research abilities such as [4]: "referencing", "selection", "interpretation", "reconsideration", "topic generation" and "validation". By content organization, we mean to organize chapters, sections and paragraphs of contents in such a manner that the outcome can yield a reasonable effect for the learner from the viewpoint of his/ her objectives, reasoning styles and text organization perspectives.

In the meantime, intelligent content organization focuses on knowledge representation schemes such as: frame and ontology and methods such as case-based reasoning, etc., which can be used for issues such as representation and inference with regard to content.

The organization of the paper is as follows: section2 explains some existing approaches to organizing research support contents. The proposed framework based on projection from content space and learner's reasoning style onto expected research abilities is discussed in section 3. Section 4 addresses the expansion of proposed framework into e-learning environment, and finally concluding remarks and future prospects are presented in section 5.

II. Existing Approaches to Organizing Research Support Contents

As content organization has a significant role in improving learning and research abilities of user both in its classical and virtual formats, various perspectives and objectives would have impacts on realizing the whole process. It is to be noted that, the combination of a content type and utilization context from one side and content processing necessities including inference and representation from the other side, can determine the appropriate approach of content organization.

In this paper, we consider "text" as a content type and "e-learning / e-research" as a utilization context. Figure 1 illustrates the ontology of content features and context perspectives in details.

In addition to the above mentioned perspectives, there exists "content processing" perspective, which investigates the content organization approaches from inference and representation viewpoints. Figure 2 illustrates the ontology of content processing perspective in details for the purpose of organizing research support contents in e-learning environment. Having a survey on the related existing approaches, reveals that the most important differentiation between the existing content organization methods, both in inference and representation perspectives, returns to the methodology.

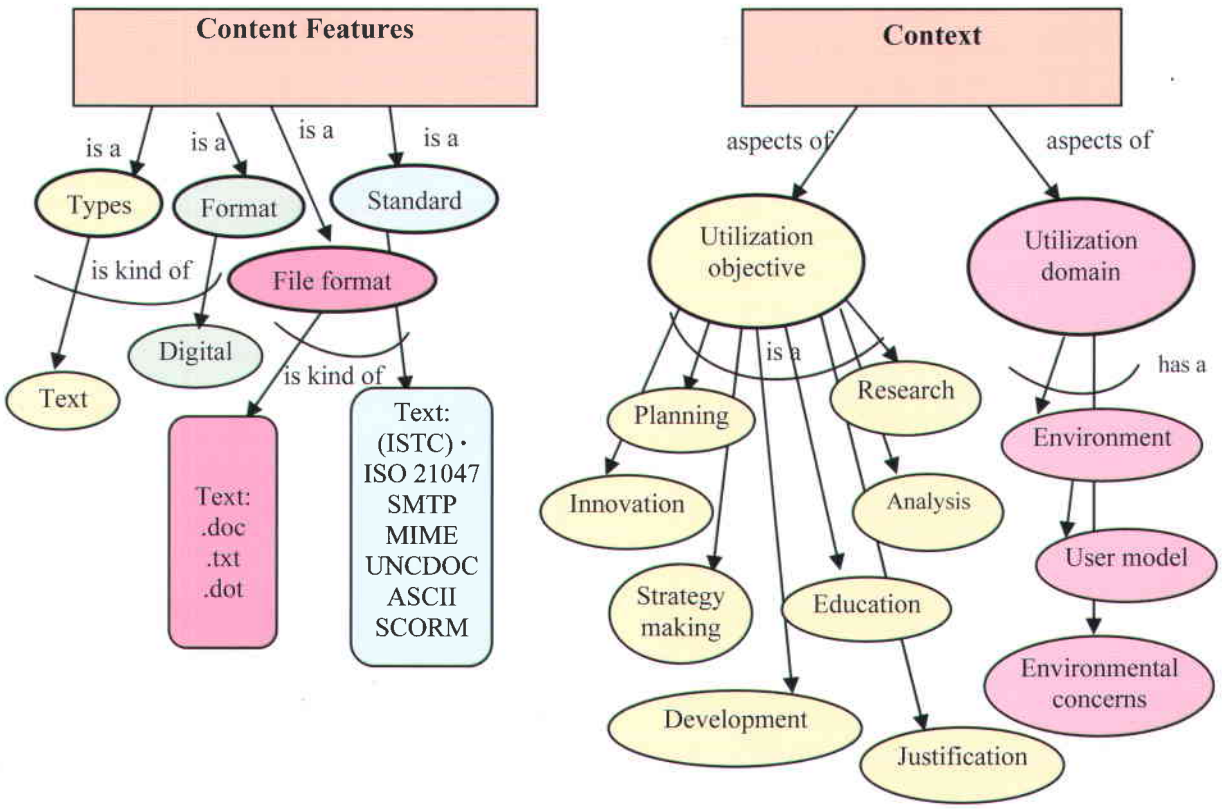


Figure 1. The Ontology of Content Features & Context

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By methodology, in inference perspective, we mean the paradigm, reasoning style, mechanisms and formats of content organization, while in representation perspective, framework has a significant role in determining the methodology of representation. Some of the existing approaches with respect to the mentioned perspective are as follows:

- With respect to "mechanisms": mining, text retrieval, natural language processing and compositional methods can be enumerated.

a) Text retrieval is used in situations where a huge database of unstructured texts (such as news) exists. These methods usually employ question-answering and query interpretation to retrieve appropriate texts. Some of them use keywords to shape dependency graphs [5], while the others make use of link analysis [6] or TF-IDF and LSI [7] to improve retrieval.

b) Natural language processing/generation (NLP and NLG) are the most commonly used methods for content organization [8]. There exist also some other NLP-based algorithms for text analysis, generation and machine translation. Among them, context free grammars together with statistical methods are mentionable [9]. It is to be noted that, these methods are not only used in summarization but are also used for simplification and discourse analysis [10]. Genie is a system which is developed based on this method for interactive environments [11]. There is another system for generating non-english texts, which is developed for search engines, online marketing and dynamic document generation [12].

c) Text mining methods are widely used for retrieval [13], extraction [14], classification [15,16] and clustering [15, 17] of different documents and texts specifically on internet [18]. It is obvious that these methods can facilitate the organization and retrieval of appropriate texts based on the user's request [19].

d) Compositional method includes fusion, integration, blending, concept composition and mash up, which are widely applicable in organizing texts specifically from the pre-experienced ones.

Blending is generally represented in two forms of structural and conceptual based on the linguistics concerns. GOFAI which is developed based on this method generates poems by applying logical data structures [20]. Integration, as well as blending applies cognitive linguistics to project from one space onto another to generate creative stories [21], to generate dynamic web contents [22] and to merge solution graphs via inexact matching [23]. In this respect, designing with blends can be a conceptual foundation of human-computer interaction [24]. Fusion methods are widely used in generating, interpreting and multi-document summarization. Multi Gen which is developed for news summarization is a sample of these methods [25]. Sentence fusion is also another method of this type, which is used for generating meaningful texts for the user's requests [26]. Also the sentences can be fused via dependency graph compression which has been implemented on a corpus of biographies in Germany [27]. Concept composition by applying frames of concepts and conjunction structure is in the meantime capable of generating new contents and ideas which have an important role in decision support systems [28]. Mash up is a new compositional method which is used for organizing multimedia contents in weblogs and forums that facilitates the reusing web contents [29]. It has been applied for educational purposes through textual editor [30].

- With respect to "paradigm": symbolism (including rule-based, case-based, etc.), connectionism (including neural network, etc.), interactionism (including multi-agent systems, etc.) and bio-inspired (including genetic, artificial immune system, etc.) can be enumerated as realms for selecting appropriate algorithms for content organization. A survey on existing research works reveals that there are rule-based or case-based algorithms for generating learning/ research contents [31, 32], while neural networks and neuro-fuzzy algorithms are mostly used for classification purposes [33]. Multi agent systems are also appropriate for patent document analysis [34] and even for story generation [35]. Bio-inspired algorithms such as ant colony [36], genetic algorithm [37] and artificial immune systems [38] can in the meantime be regarded as the algorithms which are widely used for text generation and categorization specially in adaptive sort of learning.

- With respect to "reasoning style": induction, deduction, analogical and abduction are mentionable which have a promising role in forming various parts of content based on the learner's intension. Inductive reasoning is mostly used in documents classification and clustering [15, 39], deductive reasoning via rule-based algorithms is usually applied in supporting the generation of tutoring contents [40]. Analogical reasoning is also workable for reusability of contents in e-learning environments [41] and tutoring libraries [42], and finally abductive reasoning is useful for medical diagnosis [43] and ambiguity finding in text mining [44].

- With respect to "format": predetermined format based on user learning style [45] or undetermined, via heuristic methods [46], fuzzy methods [47] and probabilistic methods [48] are mentionable.

A variety of aspects lie behind "representation" of contents, such as tools, learning theories, standards, learning styles, architectures and methodology, out of which "framework" as a subtype of methodology has a promising role in content formation and storation. It can be realized through "procedural" representation like rule-based methods [49] and smart text editing [50]. "Network representation" including conceptual graph, ontology and semantic net are also mentionable for representing contents semantically in personalizing learning [51], organizing content [52], adapting content [53], and developing content [54]. Also, in "structured representation", content can be represented in one of the forms of frame, schema and script [55].

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Also, learning style [56] from one side and learning theory [57] from the other side are some other items which have a promising role in representation of organized adaptable contents.

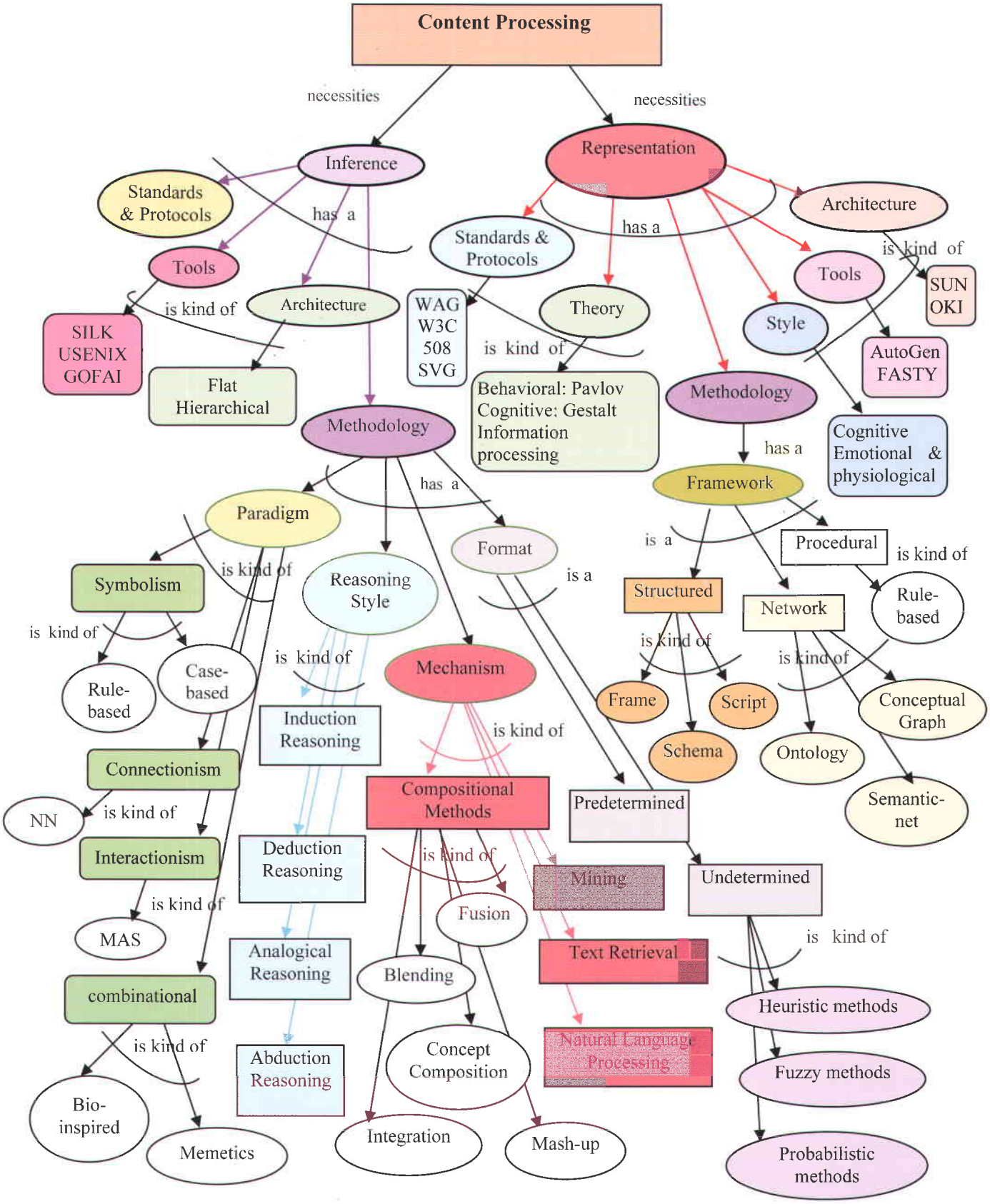


Figure 2. Ontology of Organizing Research Support Contents in E-learning Environment

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Investigating the existing approaches to content organization from different perspectives, reveals that the major concerns for well-reputed algorithms can be summarized in Table 1:

Table 1. MAJOR CONCERNS FOR WELL-REPUTED ALGORITHMS

Natural Language Processing (NLP)	Complexity in processing contents, high amount of cost for processing contents, depending on grammar of language, inability to on-line response to requests
Text Retrieval	Dependency on the query's keywords and ranking algorithms
Text Mining	Difficulties in exploring the existing regularities in contents
Text Composition/ Integration/ Fusion	Difficulties in structuring semantic dependencies by tree, graph, etc.
Rule-Based Algorithms	Difficulties in defining appropriate rules in the situations where many rules are available
Case-based Algorithms	Difficulties in defining and managing cases with the purpose of generating new solutions through adaptation
Neural Networks	Difficulties in training and organizing networks with the purpose of generating various outputs
Multi Agent Systems	Difficulties in managing and coordinating agent's outputs for the purpose of making coherency
Bio-Inspired	Difficulties in optimizing contents in the situations where input data have high entropy

As it is seen from the table, when adaptation, personalization and reuseability of contents are considered, case-based algorithms, which are capable of using pre-experienced contents, would become significant. In the meantime, when online answering to user's request is regarded, NLP is not appropriate, instead text retrieval and mining can have a significant role. Also, rule-based algorithms can widely used for content organization purposes as they are remarkably understandable, and bio-inspired algorithms are appropriate when a huge dataset of documents is available. At the end, where content assessment & evaluation is of importance, multi agent system can function well.

III. PROPOSED APPROACH BASED ON PROJECTION FROM CONTENT SPACE & LEARNER'S REASONING STYLE ONTO EXPECTED RESEARCH ABILITIES

The prime function of research support content is to provide suitable conditions for a spectrum of different researchers with different reasoning styles to achieve certain abilities for doing research. This necessitates a systematic method for organizing the research-support content from three aspects of "content's features", "content processing" and "researcher's reasoning style" (Figure 3).

By "content's features", its chapters, sections and features, which are to be considered in its organization, are meant. These major features are: "Introduction", "To-Issue", "Application", "Advantages and Disadvantages", "Topic generation" and "Reference" [4].

"Introduction" is responsible for providing a brief and overall explanation for a certain research issue. "To-Issue" includes a spectrum of approach, framework, method and tools, which is responsible for providing detailed explanation with respect to the way a certain issue can be materialized. "Application" is responsible for explaining the possibility of applying a certain issue from the viewpoints of its scope and objectives. "Advantages and disadvantages" and instead are responsible for explaining the possible advantages and disadvantages in different contexts. "Topic generation" is responsible to study the possibility of applying a certain issue for a variety of entities and for future research applications. Finally, "Reference" is responsible for indicating major references for deepening contents.

With respect to "content processing" perspective, all the aspects presented in chapter2, including methodology from both "inference" and "representation" perspectives, are considered.

"Reasoning style" is something that exists in the researcher and can affect the features that have to be organized in the content. For instance, if the reasoning style of researcher is domain-based, then "algorithms and tools" in content should be explained more precisely, while, if the reasoning style is formal, more focus should be on "approach", "framework" and "algorithm" as well. Experimentation, affects "approach" and "framework" parts of content and finally scenario-based reasoning is supposed to have impact on "approach" part in the content.

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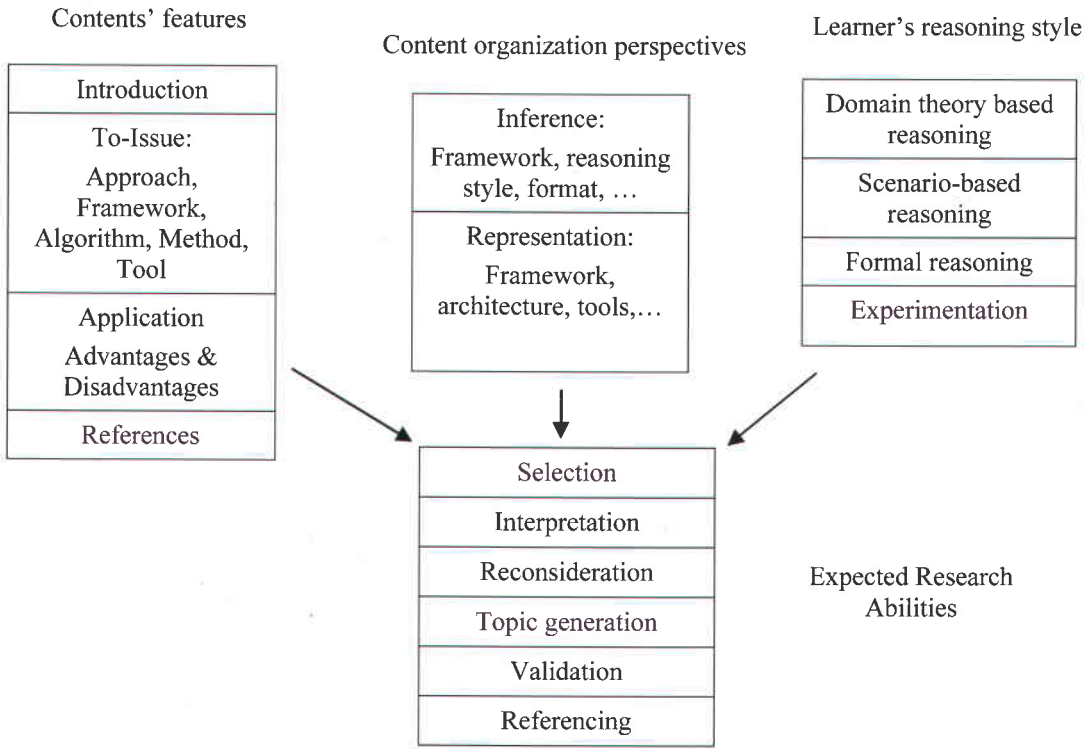


Figure 3. The Projection from Content Space onto Research Ability Space

The ground for such information is the common sense of the research specialists in general, who are familiar with the general peculiarities of these reasoning abilities.

Provided that research ability is something to be obtained by the researcher and can shape the existing research activities, the types of research ability considered in our framework can be summarized as follows [39]:

- "Selection" is the ability of selecting the relevant part of content relevant to the request of learner.
- "Interpretation" is the ability of interpreting intermediate results in research.
- "Reconsideration" is the ability of reconsidering existing methods based on the observed difficulties.
- "Topic generation" is the ability of generating new relevant research topics.
- "Validation" is the ability of validating the existing hypothesis.
- "Referencing" is the ability of finding relevant references.

Regarding the above definitions, to shape specific research ability, various features in content have to be considered and improved. With respect to "selection" research ability, "introduction", "approach", "framework" and "application" are among major features to be considered. While with respect to "interpretation" research ability, besides "introduction", "approach", framework" and "tools" should be added. "Reconsideration" research ability may be formed and enhanced through "introduction", "framework", "approach", "tools", "advantages & disadvantages". Besides, "topic generation" may be affected by "introduction", "approach", "advantages & disadvantages", "application", and "concluding remarks". "referencing" research ability is also structured by "reference" part in content and finally "validation" research ability seem to be realized through "introduction", "framework", "approach", "tools", "advantages & disadvantages".

To organize the research support content in a systematic manner, it would be important to realize the way the ensemble of a certain research ability and reasoning style together with content processing perspectives can be projected onto a number of content features. Table 2 reveals the relations between the content's features, content processing perspective, reasoning style and expected research abilities.

To implement this projection systematically, "if-then" rules may be useful. Regarding this, "If" part includes expected research abilities, while "then" part includes reasoning style, content processing perspectives and content's features. For instance: IF "Selection" reasoning style is considered, THEN any type of Learner's reasoning style including "Domain Theory based Reasoning", "Formal Reasoning", and "Experimentation" can be satisfied by "framework", "reasoning style", "format", "representation and "mechanisms" as content processing perspectives, while content's features have to be "introduction", "approach", "framework" and "application". Enhancing these features is realized gradually based on the feedbacks obtained from the researchers who study organized contents. Soft computing algorithms seem to be appropriate alternatives for optimizing these rules.

This framework can facilitate research process automatically where it makes use of self-adjustment and self-modification based on the received feedbacks from researchers. That may also be an appropriate way

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for producing the "if-then" rules, as well as seeking a strategy to organize research support contents.

Adjusting the research program based on the learner's reasoning style and expected research activity will form his/her research abilities. Besides, utilizing a derivated computational system may gradually refine the rules of study and affects its infrastructure.

Table 2. RELATIONS BETWEEN CONTENT SPACE, REASONING STYLE AND EXPECTED RESEARCH ABILITIES

Expected Research Abilities in Learner	Learner's Reasoning Style	Content processing perspectives	Contents' features
Selection	Domain theory based reasoning Formal reasoning Experimentation	Framework, reasoning style, format, representation, mechanisms	Introduction, approach, framework, application
Interpretation	Domain theory based reasoning Formal reasoning	Framework, reasoning style, format, representation, mechanisms	Introduction, approach, framework, tools
Reconsideration	Formal reasoning	Framework, reasoning style, format, representation, mechanisms	Introduction, approach, framework, tools, advantages & disadvantages
Topic generation	Domain theory based reasoning	Framework, format	Introduction, approach, advantages & disadvantages, application, concluding remarks
Validation	Formal reasoning	Framework, reasoning style, format, mechanisms	Introduction, framework, approach, advantages & disadvantages, tools
Referencing	Domain theory based reasoning Formal reasoning Experimentation	Representation	References

IV. EXTENDING THE PROPOSED APPROACH INTO E-LEARNING ENVIRONMENT

The proposed framework might be an appropriate infrastructure for designing e-learning environments. For instance, if a learner with domain theory-based reasoning style intends to improve his "selection" research ability, the organized content for him/her should include the parts of "introduction", "approach", "framework" and "application". Text mining algorithm seems to be a good alternative for "framework" part and rule-based representation in a predetermined format may be suitable alternative for "representation" perspective.

Another example regarding the proposed framework is enhancing "representation" research ability in a learner with formal reasoning style. To do that, the organized content should additionally have "advantages and disadvantages", too. In this way, "text mining" can be selected as the framework, "induction" as the reasoning style, "predetermined" as format, and finally "rule-based" can be selected as the representation.

Several benefits may come out of designing research support systems based on such a framework. The major benefits may be enumerated as: dynamically organizing research support content according to user's reasoning style and intention of research. This may yield considerable saving in cost, time and energy of a research process, and in the meantime outstanding improvement in research performance within a wide range of research contents.

Adjoining research support functionalities into existing e-learning systems necessitates some considerations.

The relations between triple aspects of content's features and reasoning style on the one side and learner's abilities on the other side, determine how the ensemble of certain research ability and certain reasoning style, utilizing certain content processing perspective can be projected onto a number of considerations regarding the content's features [4].

It is obvious that, there may be a number of patterns, each describing the associations between the above mentioned spaces. Intelligent methods with learning capabilities are preferred to handle this process dynamically in an online form.

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The combination of learner's research intention with a special methodology from content processing perspectives, will construct the various parts of research support content systematically. To realize that, content should have the following parts:

- "Introduction" on research subject including description, illustration and example.
- "Approach-Tools" with the ingredients of "approach", "framework", "method" and "tools".
- "Applications" with respect to other related issues or contexts.
- Corresponding "Advantages & Disadvantages" of each method.
- "Topic generation" regarding the discussing research issue.
- "References" related to the research issue.

Figure 4 illustrates the significant elements of organizing content dynamically.

Regarding the above mentioned points, to systemize the whole process, some other points should also be taken into consideration [3]:

- "Major issue of content" may be evolved through a) off-line organization under expert's monitoring and storing in data base, b) online organization via interaction with user and receiving his/her feedbacks, c) online organization through semantic similarity checking between "major concerns" and "basic constituents" of the selected research issue, which may be represented by frames of concepts or related ontologies.
- "Introduction of major research issue" may be realized online through summarization, classification and text mining methodologies.

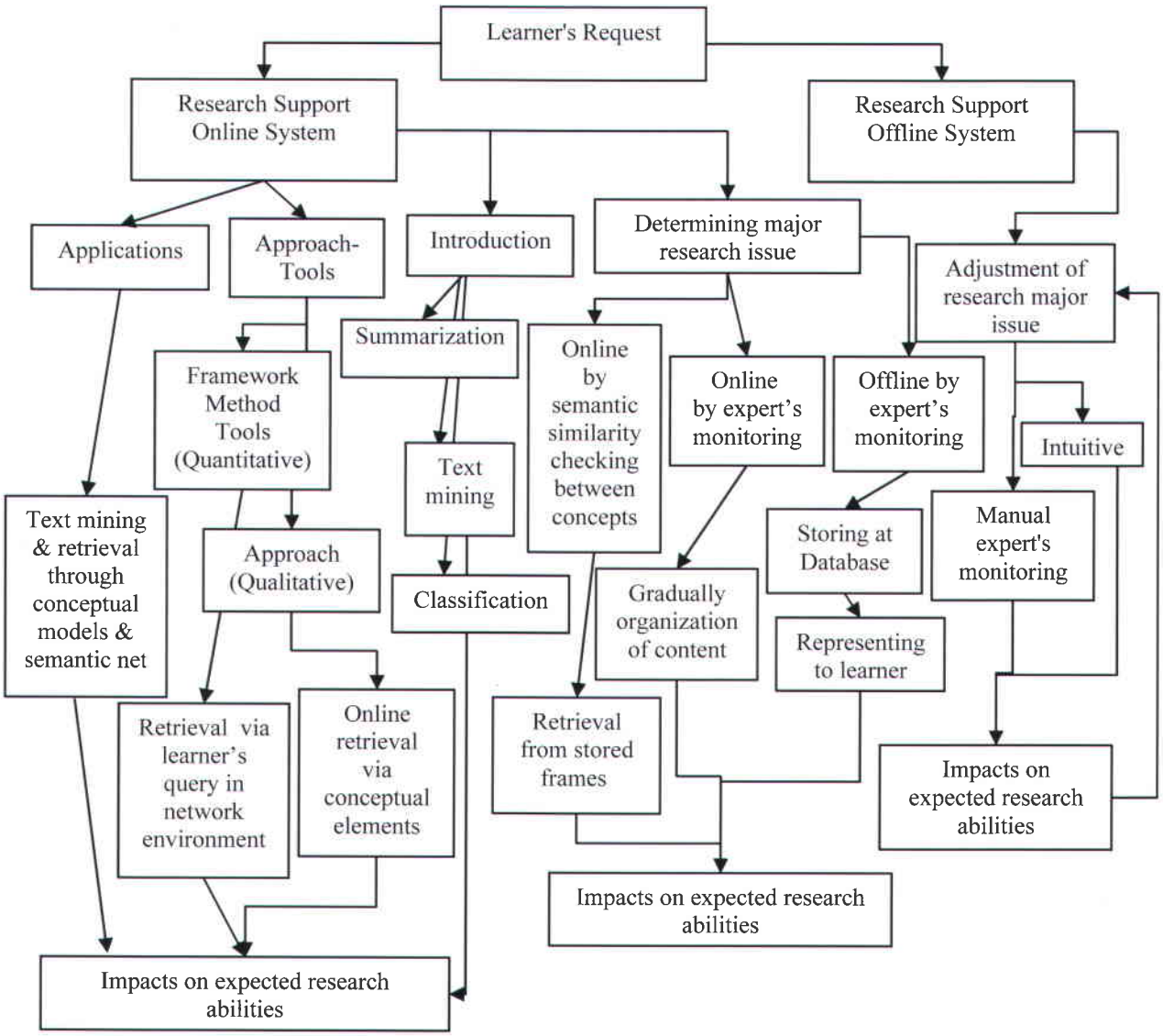


Figure 4. Significant elements of organizing content dynamically

- "To-Issue" may be generated dynamically. In this respect, "Approach" is descriptive and qualitative like "Introduction", some conceptual elements are capable of generating "To- Issue"

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in online form. In spite of that, "Framework", "Method" and "Tools" tend to be quantitative, so they can be derived from database by appropriate queries. Intelligent information retrieval algorithms may also have a significant role in indexing, ranking and retrieving the corresponding contents as responses to learner's query.

- "Application" may be organized systematically through summarization of related conceptual content parts with respect to various utilization contexts such as: economics, industry, medicine/biology, education/pedagogy, security, communications, etc.
- "Advantages & Disadvantages" may be organized online through semantic mining and retrieval.
- "Topic generation" may be structured dynamically through observing the trend of generating the research issue by saving the whole experienced research process in the system.
- "References" may be easily found by research and retrieving the references related to the major research issue.

As a conclusion, the significant role of artificial intelligence and soft-computing algorithms in online content organization through "search", "retrieval", "content summarization & mining" have not to be disregarded. Appropriate content processing perspectives included in inference and representation (as illustrated in Figures 1 and 2), facilitate content organization in an online e-learning environment.

It is obvious that, query processing and expansion using NLP and semantic web may also have significant impacts on intelligent information retrieval, content summarization, text mining and text interpretation as well.

Utilization of adaptive soft-computing algorithm (such as: neural networks, fuzzy, genetic and case-based reasoning) is also expected to have remarkable impact on text classification performance. They can also improve finding the corresponding regions of content as responses to researchers' queries based on learner's model and his/her expected research abilities. As the final point, it should not be neglected that observing cognitive considerations in representing contents may also affect remarkably the performance of a research support system.

V. CONCLUDING REMARKS AND FUTURE PROSPECTS

A framework for organizing research support contents in e-learning environments for online purposes was proposed. It was shown in the paper that the features for organizing such types of content should have the potential of enhancing research abilities in learner based on his/her intention of research and reasoning style. Our proposed framework suggests that generating some metadata to describe contents is a crucial necessity for any online system with the aim of research support. These meta data ought to be produced based on the three orthogonal aspects of "content processing", "features" included in content and "learner reasoning style". It is also possible to provide a more facilitated and well-equipped platform by applying artificial intelligence and soft computing algorithms in order to enhance researcher's mental abilities.

There are several benefits provided by this platform, out of which the most significant ones are: organizing research support content dynamically according to user profile, considerable saving in research cost, time & energy, and drastic improvement in performance of research environment. The infrastructure of a promising information society is expected to be formable based on such research environments.

In order to improve the accuracy of the framework, we recommend some further research works to modify the aspects' features by applying some learning methods like case-based reasoning and reinforcement learning. In addition, we may enhance the effectiveness of the suggested framework by utilizing some feature selection algorithms on user profile in order to assure selecting more efficient features.

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Maryam Tayefeh Mahmoudi is a Ph.D. candidate at department of machine intelligence in the University of Tehran majoring in artificial intelligence with emphasis on intelligent organization of educational contents. Within the past years, she has been involved in a variety of research works at Knowledge Management & e-Organization Research Group of IT Research Faculty at Research Institute for ICT (ex ITRC), working on issues like automatic generation of ideas and contents, decision support systems for research & education purposes, as well as conceptualization of IT research projects. She is a co-author of many research papers in different journals and proceedings of conferences.



Fattaneh Taghiyareh is Assistant Professor of Computer Engineering-Software & Information Technology, at the University of Tehran, where she has served since 2001. She received a Ph.D. in Computer Engineering- Parallel Algorithm Processing- from the Tokyo Institute of Technology in 2000. Her research interests include Human-Centered Computing applied to Learning Management Systems and based on Multi-Agent Systems. She is currently working on "Group Collaborative Learning" as well as "Educational Data Mining (EDM)" with a pedagogical approach. In addition, Web Services are also another concern of her research to solve the composition problem from an ontology-based perspective. She was ex manager of the Department of Information Technology at the School of Electrical & Computer Engineering, University of Tehran, and former Director of Technology Incubator, the University of Tehran. She is a member of Editorial Board of International Journal of Information & Communication Technology. Currently she is serving both Software Engineering and Information Technology Departments as a member and she is supervising more than 10 post- graduate students of the Multi-Agent System Lab and HCC Lab has also been founded by her. Moreover, she is supervising IT Foundation lab which was established also by her 5 years ago. She is the author of more than 50 conference and journal papers.



Babak. N. Araabi was born in 1969 in Tehran, Iran. He received the B.Sc. degree from Sharif University of Technology, Tehran, Iran, the M.Sc. degree from University of Tehran, Iran, and the Ph.D. degree from Texas A&M University, TX, USA, in 1992, 1996, and 2001, respectively, all in electrical engineering. In January 2002, he joined the School of Electrical and Computer Engineering, College of Engineering, the University of Tehran, where he is currently an Associate Professor and director of graduate studies at the College of Engineering. He is also a Senior Research Scientist at School of Cognitive Sciences, Institute for Research in Fundamental Sciences (IPM), Tehran, Iran. Dr. Araabi is the author or coauthor of more than 60 international journal papers in his research areas, which include machine learning, pattern recognition, machine vision, decision making under uncertainty, neurofuzzy systems, fault diagnosis, prediction, modeling and systems identification.

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