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Ontology-Based Design of the Learner's Knowledge Domain in Electrical Engineering

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***Abstract* – This research addresses some personalization aspects of education in electrical engineering. Its goal is to help students and educators evaluate the complexity of the disciplines they have chosen for studying and optimize the order of the learned courses and topics. A new instrument, namely, an educational thesaurus, is presented and its assembling procedure is shown. The offered educational thesauri implemented in the labs and integrated in the exercises have become smart platforms suitable for design and management of the students' individual knowledge domains. The ontology-based Web manuals in Electronics and Power Electronics for the Bachelor study cycle have been introduced. An example of ontology graph to be applied within the Master study cycle has been developed and explained in the paper. According to the authors' investigation, the decrease of stress caused by the new educational environment and achievement of success in learning were observed thanks to the individual knowledge domain organization proposed in this study.**

***Keywords* – Distance learning; Education courses; Engineering education; Engineering students; Learning management systems; Ontology; Thesauri.**

I. Introduction

New informational environment opens great opportunities for open education. Traditional classes are replaced with Massive Open Online Courses (MOOCs) and Learning Management Systems (LMSs) shared among multiple universities around the world [1]. Traditional strictly organized curricula are forced out by "a la carte" menu-like study plans based on learners' preferences and interests. Owing to the fact that the course materials are available at any time and any place, students may decide themselves when, how, in which order, and at which rate to study.

MOOC and LMS frameworks have obvious and prominent benefits demonstrated and discussed, in particular, in [2], [3]. Rapid automatic grading, instant scoring and feedback, storage, reusability, and scalability of student results dramatically accelerate material assimilation and appreciation of difficult topics. Audience and personal response systems in large classrooms, electronic screens, and sensor boards change the requirements towards such students' talents as memory, intelligence, logical thinking, gumption, and acumen. Learners' mindset has become specific, algorithmic, colour- and movie-based, game-oriented, and emotional. Moreover, multiple IT solutions offer easy data search compared to handwriting papers, allow for a wider range of tasks and activities that can enable educators and learners to discuss their problems in the environment appropriate for teaching and assessments.

New course design implies new content, structure, and information delivery. There is a widespread transformation of the courses in flipping and self-directed blocks. A new course consists of mosaic topics instead of basic units. Teaching hours are filled with presentations with animations, simulations, and videos instead of lectures and exercises. Millions of options concentrated in numerous podcasts are available at video-sharing resources. Lecture notes either disappear or undergo dangerous simplification being replaced with chats and similar communication tools.

The new role of educators is becoming evident. They increasingly become service personnel instead of the "big shot". Instructor inability to control the learning process to the extent characteristic of traditional teaching is becoming an influential trend. Course methodology is replaced by the articles from Wikipedia for the sake of receiving a student's "like" in return for the teacher's evaluation. Lack of personalization and bad verification of student's identity in view of multiplicity and diversity of participants become increasingly threatening.

However, such studies as [4], [5] note that the new learning technology faces such challenges as low completion and retention rates, certification, graduation, and verification of student's identity, and unsuitability for complex and engineering education. Nevertheless, this process continues expanding despite declining educational attainment in these spheres [6]. A large number of dropouts, especially in engineering education, which within certain MOOCs may reach 97 % [7], [8], is the most dangerous problem. It is noteworthy that students' dropping out of MOOCs and LMSs is often conditioned by different reasons than in case of onsite education, partly due to inappropriate course methodology, deficiency of social interaction and creativity, and lack of personalization. It is a widespread tendency that many learners have gaps in their knowledge because of the unordered movement across the curriculum. Difficulty with math is a popular reason why engineering students are not able to learn. Moreover, some entrants do not possess sufficient skills in reading, writing, simulation, calculation, and even typing [9].

Many research papers are devoted to the exploration of motives that drive students to enrol in one or another e-course and the reasons of their failure. In [4], lack of student's motivations is identified as an influential factor in preventing

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students from completing their education. Time limitations required to finish a course is mentioned as another significant factor preventing students from completing their education. Feeling of isolation and lack of interactivity are among other factors having a direct effect on students' dropout of distance learning. They involve low interaction and poor feedback between the lecturer and students on the one side and absence of teamwork and communication among course participants on the other side. In [10], the costs that are required to pay by students to get their certificates or to purchase textbooks recommended by lecturers are shown as another reason that may cause high student withdraw rate.

Among the factors, motivating students to withdraw from studies, authors of [11] indicate course design, including its content, structure, and information delivery. Such issues related to the course design as "the courses were too complex or technical", "the language used was too complicated", "the course had too many modules", etc., were noted by [12] in the reports on students who did not complete learning.

Specifically, it concerns the students participating in different study exchange programs. They have to choose among the courses that often are poorly interconnected one with another and with the disciplines of their home universities. Additionally, a foreign language contributes to the problem.

Students' inability to navigate in this framework and failure to choose an appropriate course and lesson sequence result in insufficient background and skills [13]. As a consequence, if some new subject matter comes up that is not immediately and totally clear (which is highly likely in the context of university education), and students do not have the possibility to ask, they miss out on the fundamentals that often are a prerequisite for whatever comes next. The authors of [14] lament that such learners take a rather passive role, more or less attentively consuming whatever is presented to them instead of actively grappling with the new information. This phenomenon results in the learners' frustration and stress, as well as the teachers' overload and dissatisfaction.

This research concerns one personalization aspect of learning and, partially, e-learning aiming to help students in evaluation of the complexity of the particular disciplines and in optimization of the order of the learned courses and topics. Development of individual educational trajectories offered in this study is intended to help students decrease the stress caused by new educational environment and achieve success in learning. Based on ontology, the approach is considered suitable for study organization based on concepts and their relationships.

The paper is organized as follows. First, the drawbacks of conventional curricula arrangement from the ontological point of view are explained. Then, an educational thesaurus is presented along with its assembling procedure and a case study in Electronics. Next, implementation of the educational thesaurus in design of a personal knowledge domain is offered.

II. Analysis of Ontologies Used in Education

Learning is based on a succession of knowledge acquisition modules, such as disciplines, courses, textbooks, manuals, etc. that help students obtain a new appreciation of the universe. Schooling, study, observation, and practice supply learners with concepts. As a student passes from one module to another, the number of known concepts grows gradually. The focus is on finding the cheapest and shortest ways for a student to become competent in the future profession.

An ontology approach became an advanced technology in knowledge engineering; it enables efficient knowledge reuse and sharing by defining, manipulating, and managing concept and their relations [15]. Ontology represents a compendium of knowledge having structured controlled relationship of concepts within some knowledge domain. Ontologies formally consider every academic module as a knowledge domain. Many authors wrote about possible applications of ontology in education; much research was concentrated on ontologies in learning, teaching, and assessment. Many toolboxes were developed for managing educational ontologies. Visualthesaurus.com intended for studying languages, RDFS and OWL for medical education, and some Wikis, for example, wiki.dbpedia.org/Datasetscitation [16] are among them. Ontologies successfully integrate multiple hypermedia systems with AIMS (topic maps implemented in the domain models) and OntoAIMS (OWL and DAML-S) languages.

However, selection, validation, and verification of the concepts are a complex and sometimes impossible problem [17]. Usually, educators use ontologies created by domain experts, who are considered authorities in the appropriate field of science. The same method is used for developing study materials and tutorial aids, instruction manuals, as well as for students' guiding [18]. Often, it is done manually and is deemed as a very time-consuming and labour-intensive process. This is the reason why data overload and students' disorientation are observed in modern engineering education that relies on the Internet and virtual resources. Therefore, instruction loses its attractiveness and clarity.

Our analysis addressed the following problems related to numerous Bachelor and Master level courses:

- poor interconnection among the contents of different courses often leads to disregarding of the interdisciplinary links;
- course syllabi frequently repeat one another to a great degree;
- inflexible discipline structures are unsuitable for customization and adaptation to learners' personal profiles.

The above-presented analysis may be concluded with the following consideration.

1. Often, *concepts in education are defined via their parts*, for example, "A transistor is a device consisting of emitter, collector, and base". In this case, the concept cannot be recognised until the reader knows its parts.
2. As *recursion* is not prohibited in course topics, any concept may be indirectly determined by itself. For example, "A diode includes anode". "An anode is a part of the diode".
3. Some definitions are based on *neglecting*, when a concept is determined through a neglecting concept. For instance,

"False is not True". It means, to understand the concept, recognition of the opposite concept is needed.

4. In many cases, explanations remain *indifferent to synonyms*. For instance, Wikipedia.org determines the same concept independently in different articles.
5. Commonly, the courses do not encourage *redefining* of the concepts. When definitions are absolute, they are hard to adapt to the learners' knowledge diversity.

Hence, traditional course arrangement does not meet the learners' needs from the ontology point of view, thus preventing student success in learning. Such organization is more or less appropriate for educators and administrative staff rather than for learners in need of continuous enhancing their knowledge base. Therefore, a novel approach is required.

III. Design of the Educational Thesaurus

Using ontological approach, all concepts from the learner's knowledge domain have to be classified as either known or unknown ones (Fig. 1), and some terms should be introduced. The concepts beyond the studied module are named *outside concepts* here. It is presumed that the meaning of the outside concepts was discusses in the previous modules. As well, the concept, the meaning of which is studied in the current module, is named a *defined concept*. Along with that, all entries introduced earlier that are used to explain the defined concept are named *parents,* whereas the entries generated from the defined concept are named *kids*.

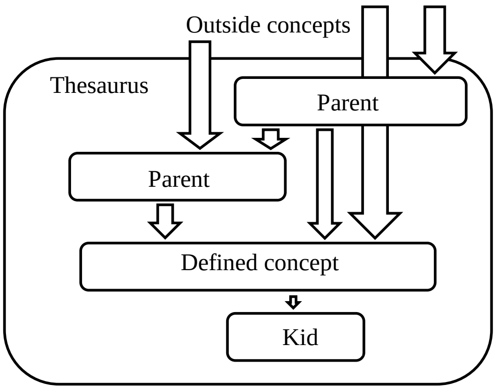

Fig. 1. A learning module as ontological knowledge domain.

Ontology may be represented as a thesaurus [19], which involves m defined concepts. A separate concept, CON_i, is shown as an i-th thesaurus entry as follows:

$$CON_i = \{i, Term_i, D_i(T_{i1}...T_{it}, P_{j1}...)\}. \quad (1)$$

Here, $i = 1 ... m$ is an index; *Term* denotes the defined concept; D explains the concept meaning; T_i stand for the parent terms in D; P_j stand for the terms denoting outside concepts in D; $T_i, P_i \neq Term_i$, $t < m$.

These entries are linked with each other directly and/or indirectly. A body of the knowledge acquired from this ontology depends on the student understanding of the concepts ($T_{i1}...T_{it}$) that are used in definition D. Any unknown T_i item impedes the progress in learning.

We call the new tool for ontology building an educational thesaurus (ET) because it is intended primarily for teaching, learning, and assessment. The ET structure and its definition have a unique arrangement because each educational module uses the same concepts in a specific context by applying its distinctive meaning that may deviate from the meaning in everyday language and other contexts.

To overcome the deficiencies of the conventional thesauri from the educational point of view, the following main principles of ET arrangement are offered: (a) move strictly from known to unknown, (b) move strictly from simple to complex, (c) move strictly step by step, without repetitions and recursions, (d) redefinitions and use of synonyms are possible. These principles may be stated as the following set of rules:

Rule A. The input concept of the ET, CON_1, has to title an educational module based on the outside concepts ($t = 0$). That would ensure that the learners would understand the module definition before enrolment in the course:

$$CON_1 = \{1, \textit{Course title}, D_1(P_{j1}...)\}. \quad (2)$$

Rule B. Every definition $D_i(T_{i1}...T_{it}, P_{j1}...)$ has to explain the application focus of the defined concept and/or its main operation principle. To prevent the ET concept definition via its separate particles or opposite concepts, the parents have to be introduced prior to the defined concept. Algebraically speaking, a truly designed ET is to be presented as the left-triangular matrix of its terms.

Rule C. To minimise learner's efforts and shorten understanding time, the number of parents should be limited to two or three entries.

Rule D. As each synonym is considered a separate ET entry, all of them need uniform definitions in the thesaurus.

Rule E. To prevent repetition and recursion in the thesaurus, an appropriate ET design tool is required.

Rule F. Concept redefinitions are welcomed in education (in contrast to other thesauri), so every simple short definition is to be constantly improved during the course continuation.

Assembling of the ET to meet the above-mentioned rules is a problem faced by thesauri designers, which concerns the filling-in stage, the stage of edition, and the ranking procedures. Many sorting algorithms are known from literature, for example, [20], [21]. However, in contrast to the usual data list, the key of the ET sorting is to be represented by an unknown position i at which a defined concept is introduced into the student's knowledge domain. This key should be found based on the previously known terms $T_1...T_i$ that earlier determined the sorted concepts. Unless a developer introduces a concept at the proper time and place, concept doubling may occur, which may complicate understanding of the concepts. The bigger is i, the later a concept CON_i is to be introduced in the learner's domain. The research issue is to search min(i), which means the minimum permissible index of the defined concept CON_i. To rank the ET, the procedure shown in Fig. 2 has been developed.

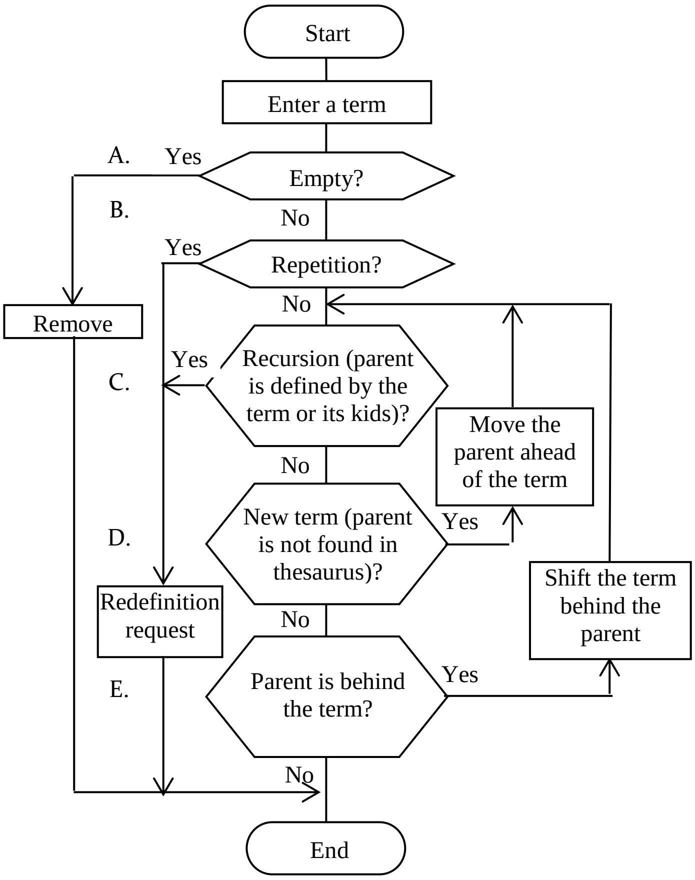

Fig. 2. Thesaurus ranking algorithm.

The procedure involves five particular cases:

A. The concepts, the terms of which are empty, have to be removed from the ET;

B. If the terms are repeated, a request for the concept redefinition is generated;

C. In case of recursion, when a parent concept is determined by the term itself or via the kids of this term, the request for the concept redefinition is generated again;

D. If a new term appears, the parent of which is absent among the thesaurus terms, this parent term is to be placed ahead of the defined one;

E. If the parent concept is found behind the defined term, this term has to be moved behind the parent.

Given the fact that i is the minimal allowed index of the defined concept, indexes i of other concepts can be exchanged later using the same algorithm. In this way, the developer obtains a tool suitable for finding the best position for every concept in the discipline.

The thesauri designed according to the proposed methodology became parts of some Web documents in the disciplines related to Electronics and Power Electronics. Thanks to their hierarchical structure, today these interactive hyperlink dictionaries interpret more than 1000 concepts; those articles have semantic (meaningful) relationships with preliminarily given definitions.

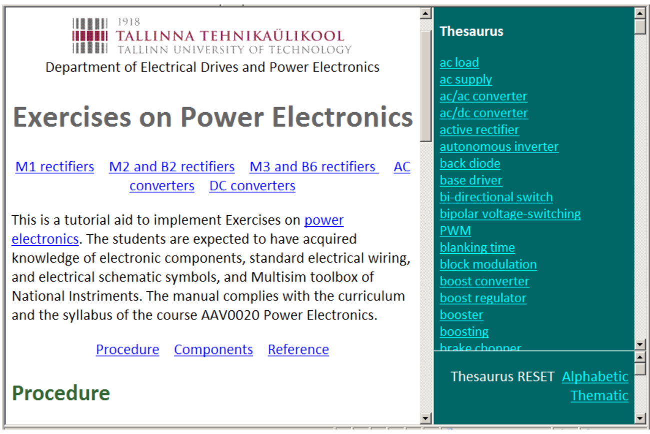

Fig. 3. Fragment of the ET-based online manual for exercises in Power Electronics.

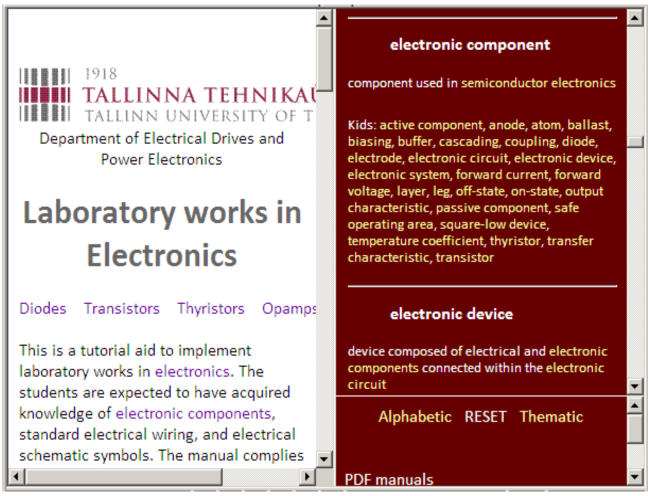

Fig. 4. Fragment of the ET-based online manual for labs in Electronics.

In Fig. 3, the screen shot of the online manual is represented; it introduces the exercises in Power Electronics with thesaurus entries in the form of the database. Fig. 4 shows a similar fragment from the labs tutorial aid in Electronics. The frames of both ETs include the following areas:

- the concept term,
- definition area where the parent concepts are displayed as hyperlinks with respective thesaurus entries,
- kids' area in which inheritable concepts are given in the hyperlink form with appropriate thesaurus entries.

IV. Design of Individual Knowledge Domains

The proposed ET became a flexible platform suitable for design and control of the student's individual knowledge domain. It helps estimate course complexity and optimize the sequence of learned disciplines.

The domain design problem is formulated as follows. Let us consider that the previously studied discipline or module is based on a system of concepts A. The new course the student decides to enrol in involves a system of concepts B, some of which may belong to the concept system A. It is required to find a link between the new course and the previously studied disciplines.

When among the concepts of system *B* there is a concept defined through the concept of system *A*, these two systems may be interconnected, and the problem solution is reduced to searching for a link between these concepts using appropriate algorithms from the theory of information, for instance, the Dijkstra's algorithm [22]. In this case, the problem lies in finding terms of *B*, which correspond to the concepts of *A*. On the contrary, when no concepts of *A* can be found among the concepts of *B*, but a concept from some other discipline *K* is found, which in turn comprises a concept from *A*, then *K* is considered an intermediary discipline, which has to be included in the designed educational trajectory. In this case, a path between the appropriate concepts in *K* is to be found with the help of the same algorithm.

For example, let us consider that the previously studied course Power Electronic Converters (PEC) involves the concepts from the following list:

1. *power electronic converter* (*PEC*) – a device to convert *energy* using a *power electronic system*;
2. *dc/dc converter* − *PEC* to transform *dc* of one level to *dc* of another level;
3. *consumer* – a device *supplied* from the *PEC*;
4. *supply* − *power* grid *which* feeds the *PEC*;
5. *switching dc converter* – a *dc/dc converter* based on the *switching* principle of performance;
6. *boosting* − generation of the *load voltage* which is higher than the *supply voltage*;
7. *booster* − *PEC* capable for *boosting*;
8. *buck converter* – a *switching dc converter* with output *voltage* less than the input one;
9. *boost converter* – the same as *booster*;
10. *buck-boost converter* – a combination of *buck converter* and *boost converter*.

In this list, the concept terms as well as the terms from the prior disciplines (*Electronics*, *Electrical Engineering*) are highlighted in italic. The defined concept terms are placed on the left, whereas the definitions of their parents are placed on the right. The graph of these concepts is shown in the upper part of Fig. 5, where the incoming terms are shown as the dotted arrows.

Let us consider a new discipline, *Energy Engineering*, that a student wishes to study. It includes, among others, the following concepts:

1. *energy engineering* – field of engineering related to energy control, energy system engineering, and environmental suitability;
2. *power station* – *energy engineering system* which generates *electric power*;
3. *renewable power engineering* – field of *energy engineering* related to *energy* from the renewable *natural resources*;
4. *windmill* – a *machine* in *renewable power engineering* which uses *mechanical energy* from a *wind turbine*.

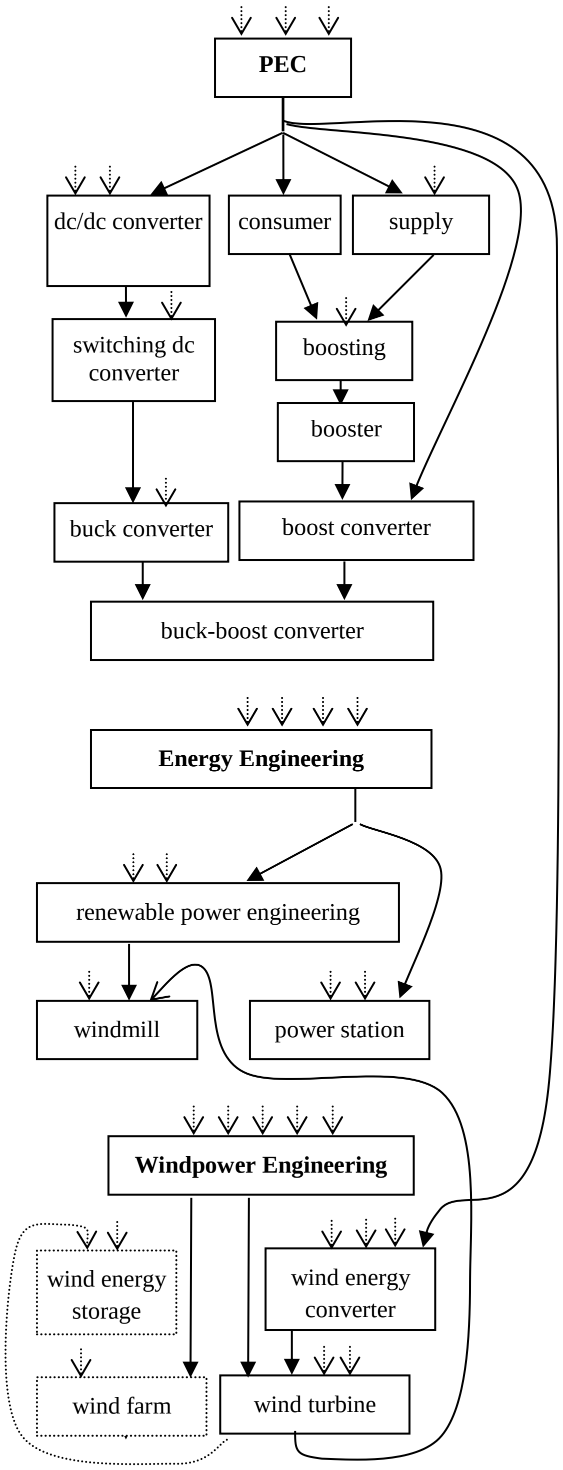

Fig. 5. Ontology graph of the ET (fragment).

Here, the concept of *windmill* is defined by means of the term *wind turbine* from the discipline *Windpower Engineering*, which may be recommended for inclusion in the knowledge domain as an intermediate discipline.

Windpower Engineering involves, particularly, the following list of concepts:

1. *windpower engineering* – the course focused on *design engineering*, *installation*, *maintenance*, and *projects* concerned with *wind power*;
2. *wind energy converter* – a device for converting *mechanical energy* to *electricity* with the help of *PEC*;
3. *wind turbine* – *wind energy converter* applied in *windpower engineering* for extracting *energy* from *wind*;
4. *wind farm* – a set of *wind turbines* in the same area for producing *electric power*;
5. *wind energy storage* – equipment set applied in *windpower engineering* to collect *electricity* from the *wind farm*.

Here, *PEC* is a parent concept of *wind energy converter* whereas *wind turbine* is a kid of *wind energy converter*. The remaining concepts of *Windpower Engineering*, such as *wind farm* and *wind energy storage*, are optional for study.

Graphical fragments of *Energy Engineering* and *Windpower Engineering* are shown at the bottom of Fig. 5.

This example demonstrates the optimal learning path allowing a student to achieve greater flexibility in education and to reduce many constraints in his/her study progress.

V. Conclusions

Despite the benefits of MOOCs and LMSs, they have to deal with such challenges as the gaps in students' knowledge and their incapacity to choose an appropriate course and lesson sequence that often result in the learners' frustration and stress as well as the teachers' overload and dissatisfaction.

Analysis of traditional educational ontologies shows that the contents of different disciplines are poorly interconnected, therefore the interdisciplinary links are often disregarded; course syllabi repeat one another to a great degree, whereas inflexible curricula structures are not responsive to change.

The stated rules of ET organization are intended to resolve the problems of conventional thesauri that are important from the point of view of education. They provide knowledge arrangement from simple to complex, from known to unknown, systematically, without recursions and repetitions, without exclusion of redefinitions and synonyms.

The thesauri developed according to the proposed methodology were worked out to accompany some Web documents in the disciplines related to Electronics and Power Electronics.

The offered ET became a suitable tool for design and control of the students' individual knowledge domain. The established optimal learning paths help in obtaining a flexible platform for all participants of an educational process, thus allowing students to have greater knowledge appreciation and reducing many constraints in their study progress. Optimal educational ways facilitate preliminary evaluation of discipline complexity and help optimize the order of the learned courses.

References

[1] A. A. Economides and M. A. Perifanou, "MOOC affordances model," *IEEE Global Engineering Education Conference* (EDUCON), Santa Cruz de Tenerife, Spain, 2018, pp. 605–613. https://doi.org/10.1109/EDUCON.2018.8363285

[2] Z. Raud and V. Vodovozov, "Remote training with self-assessment in Electrical Engineering," *International Journal of Social, Behavioral, Educational, Economic, Business and Industrial Engineering*, vol. 10, no. 1, 2016, pp. 46–51.

[3] V. Reda and R. Kerr, "The MOOC BA, a New Frontier for Internationalization," *Conf. Learning With MOOCS* (LWMOOCS), Madrid, Spain, 2018, pp. 95–97. https://doi.org/10.1109/LWMOOCS.2018.8534651

[4] F. Dalipi, A. S. Imran and Z. Kastrati, "MOOC dropout prediction using machine learning techniques: Review and research challenges," *IEEE Global Engineering Education Conference* (EDUCON), Santa Cruz de Tenerife, Spain, 2018, pp. 1013–1020. ttps://doi.org/10.1109/EDUCON.2018.8363340

[5] S. Assami, N. Daoudi and R. Ajhoun, "Personalization criteria for enhancing learner engagement in MOOC platforms," *IEEE Global Engineering Education Conference* (EDUCON), Santa Cruz de Tenerife, Spain, 2018, pp. 1271–1278. https://doi.org/10.1109/EDUCON.2018.8363375

[6] C. M. Stracke, E. Tan, A. M. Texeira, M. do C. T. Pinto, B. Vassiliadis, A. Kameas and C. Sgouropoulou, "Gap between MOOC designers' and MOOC learners' perspectives on interaction and experiences in MOOCs: Findings from the Global MOOC Quality Survey," *18th International Conference on Advanced Learning Technologies* (ICALT), Mumbai, India, 2018, pp. 1–5. https://doi.org/10.1109/ICALT.2018.00007

[7] D. Chen, Y. Feng, Z. Zhao, J. Jiang and J. Yu, "Does MOOC really work effectively," *International Conference on MOOC, Innovation and Technology in Education* (MITE), Patiala, India, 2014, pp. 272–277. https://doi.org/10.1109/MITE.2014.7020287

[8] W. Wu and Q. Bai, "Why do the MOOC learners drop out of the school? – Based on the investigation of MOOC learners on some Chinese MOOC platforms," *1st International Cognitive Cities Conference* (IC3), Okinawa, Japan, 2018, pp. 299–304. https://doi.org/10.1109/IC3.2018.00039

[9] A. Sachdeva, P. K. Singh and A. Sharma, "MOOCs: A comprehensive study to highlight its strengths and weaknesses," *3rd International Conference on MOOCs, Innovation and Technology in Education* (MITE), Amritsar, Pakistan, 2015, pp. 365–370. https://doi.org/10.1109/MITE.2015.7375346

[10] H. Khalil and M. Ebner, "MOOCs completion rates and possible methods to improve retention: A literature review," *World Conference on Educational Multimedia, Hypermedia and Telecommunications* (EDMEDIA), Chesapeake, VA, USA, 2014, pp. 1236–1244.

[11] K. Hone and G. Said, "Exploring the factors affecting MOOC retention: A survey study," *Computers and Education*, vol. 98, 2016, pp. 157–168. https://doi.org/10.1016/j.compedu.2016.03.016

[12] P. Adamopoulos, "What makes a great MOOC? An interdisciplinary analysis of student retention in online courses," *34th International Conference on Information Systems* (ICIS), Cavtat/Dubrovnik, Croatia, 2012, pp. 1–21.

[13] K. Moscinska and J. Rutkowski, "Effective computer-assisted assessment: Challenges and solutions," *IEEE Global Engineering Education Conference* (EDUCON), Santa Cruz de Tenerife, Spain, 2018, pp. 975–984. https://doi.org/10.1109/EDUCON.2018.8363335

[14] V. Thurner and S. Hammer, "Fostering questions in class," *IEEE Global Engineering Education Conference* (EDUCON), Santa Cruz de Tenerife, Spain, 2018, pp. 208–213.

[15] S. Staab and R. Studer, *Handbook on Ontologies*. Springer, 2009, p. 811. https://doi.org/10.1007/978-3-540-92673-3

[16] C. Kay, et al. (eds), *Historical Thesaurus of the Oxford English Dictionary: With Additional Material from a Thesaurus of Old English*. Oxford University Press, 2009, p. 3952.

[17] P. Velardi, S. Faralli and R. Navigli, "OntoLearn reloaded: A graph-based algorithm for taxonomy induction," *Computational Linguistics*, vol. 39, no. 3, MIT Press, 2013, pp. 665–707. https://doi.org/10.1162/COLI_a_00146

[18] R. Navigli and P. Velardi, "Learning word-class lattices for definition and hypernym extraction," *The 48th Annual Meeting of the Association for Computational Linguistics* (ACL), Uppsala, Sweden, 2010, pp. 1318–1327.

[19] J. Aitchison and A. Gilchrist, *Thesaurus Construction and Use: A Practical Manual*. London: Aslib, 1997, p. 212.
[20] N. Wirth, *Algorithms and Data Structures*. Upper Saddle River, NJ: Prentice Hall, 1986, 288 p.
[21] D. Knuth, *The Art of Programming*. Massachusetts: Addison Wesley, 1997, 650 p.
[22] E. W. Dijkstra, *Selected Writings on Computing: A Personal Perspective*. New York: Springer-Verlag, 1982, 362 p. https://doi.org/10.1007/978-1-4612-5695-3

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