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Reusable Learning Object Metadata Adaptation for Higher Education Instructional Design

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ABSTRACT
Reusable learning objects have always been adapted in e-learning environments to serve different purposes in instructional design. This adaptation process is usually limited by varying metadata standards of reusable learning objects that in most cases do not conform to the standard structure of the learning objects for a given educational level. In this paper, we present an analysis of various learning object metadata standards and propose a new metadata structure for a higher education reusable learning object. We evaluate this new metadata structure by instantiating it with a learning object authoring tool that also supports adaptation of learning objects with multi-format assets. We use expert sampling technique to randomly select 8 experts in higher education instructional design (from three different universities) to evaluate the functionality, correctness and usability of the tool in authoring reusable learning objects with multi-format assets. This process is repeated with 10 experts in instructional design, randomly selected from 5 universities. The results from the two experiments show a strong positive correlation and this proves that the proposed metadata structure can be adopted by higher education institutions in instructional design process to create adaptable reusable learning objects.

KEYWORDS

1 INTRODUCTION

1.1 Reusable Learning Objects

The definitions of the term Reusable Learning Object (RLO) provided by various scholars and educational standards organizations depend on “how the concept has been used in instructional design”[1]. For example,

i. Wiley[2] defines a RLO as “any digital resource that can be reused to support learning”.

ii. The standard for Learning Object Metadata[3] developed by the IEEE’s Learning Technology Standards Committee (LTSC) defines a learning object as “any entity - digital or non-digital - that may be used for learning, education or training”.

iii. Robbins[4] defines a RLO as “a chunk of distinct knowledge that can be kept as a resource for content designers within the Learning Content Management System (LCMS), or delivered as a stand-alone object”.

In this paper, we define a reusable learning object as a unit of electronic instructional content that can be reused to achieve a single learning objective in instructional design. Reusability of a learning object in this case is “the degree to which a learning object can work efficiently for different users in digital environments and in different educational contexts over time”[5]
For purposes of scope, this paper focuses on reusable learning objects that have the following technical characteristics:

i. White-box transparent reusable learning objects[1] that can provide access to their internal implementation (source code) to support adaptation.

ii. Learning objects that can be delivered in a web-based environment.

iii. Learning objects made up of multi-format assets. An asset in this case is the smallest unit of content that cannot individually be used to achieve a learning objective, such as an image, a source code snippet, a video or audio clip, among others.

iv. Learning objects that are decomposable into their assets to allow asset-level adaptation.

v. Learning objects with instructional content for higher education level, such as a university.

1.2 Reusable Learning Object Adaptation

Reusable learning object adaptation is the process of modifying an existing learning object in instructional design with the aim of achieving a new learning objective in the learning environment. The results of the mEducator project [6] showed that a learning object can be adapted into different contexts such as; the content itself, the language, the cultures, the pedagogical approaches, the educational levels, the disciplines or professions, the content types, the technology, and the people with different abilities.

The standard structure of a learning object makes it more reusable in various ways in instructional design. Usually, each standard learning object has two parts, the metadata and the instructional content[2]. The metadata is the data that defines the learning object so that it is easily discoverable in online learning object repositories. The instructional content part is the actual content that the author intends to use in achieving a learning objective. Thus, adaptation of the reusable learning object can be either at instructional content level or at metadata level.

At instructional content level, the instructional designer modifies existing instructional content of the learning object so as to reuse it in achieving a new learning objective in the learning environment. For example, a Java applet (as an example of a learning object) meant to teach the student how the while loop in Java programming language works (in form of a simulation) can be modified (if the source code is available) to teach the student how the do while loop works either in the same programming language or another programming language. The fact that this Java applet now achieves a new learning objective means that it has been adapted for reuse.

At metadata level, the instructional designer modifies the existing metadata structure of the learning object. This can be done by either adding new metadata elements or formulating a new metadata structure from existing metadata standards with the aim of improving reusability of the learning object.

For purposes of scope, this paper focuses on adaptation of the metadata structure of the learning object to improve reusability, specifically, learning objects that can be used for higher education instructional design.

1.3 Reusable Learning Object Metadata Standards

Various standard metadata models have been defined to support authoring of standard reusable learning objects. Such metadata standards include the Institute of Electrical and Electronic Engineers Learning Object Metadata(IEEE LOM) standard[3], DublinCore[7], Sharable Content Object Reference Model(SCORM)[8], the National Educational Technology Group(NETg) learning object model[9] and Cisco’s reusable learning object content model[10,11]. A critical analysis of these learning object metadata standards shows that:

i. They have varying metadata sets, implying different learning objects structures from one standard to another. For example, the IEEE LOM standard has 9 metadata elements/attributes[3] while the DublinCore standard has 15 metadata elements[7].
They are generic in a sense that they are not customized for a given educational level. For example, much as the IEEE LOM standard[3] provides *Educational* attribute among the 9 metadata attributes, this attribute focuses on the educational and pedagogical characteristics of the learning object but does not specifically state which educational level such a learning object is meant for. However, instructional design as a process requires articulation of instructional design requirements before the content is designed. Among these instructional design requirements is educational level requirements. It is common practice that the instructional content of one educational level has different attributes from that of another educational level. For example, the structure of high school instructional content does not necessarily have to have the same structure as university level content.

Several attempts to extend existing learning object metadata standards have not helped much to produce a metadata structure for a higher education learning object that is easy to adapt, especially learning objects with multi-format assets. For example, the extension of the IEEE LOM[5] standard by the collaborative partners of Customized Learning Experience Online (CLEO) [12] was meant “to align the metadata requirements of Cisco, Microsoft, IBM and Thomson NETg to provide a foundation for collaboration using shared content”[13] but not for a particular educational level. Another significant effort to specify the metadata structure of a higher education learning object was by Sun and Williams[11], which was an extension of the Cisco Systems reusable learning object model[10]. In this study, we further extend the higher education learning object metadata structure proposed by Sun and Williams[11] with the aim of supporting adaptation of higher education reusable learning objects with multi-format assets.

The rest of this paper is organized as follows; Section 2 presents the current metadata structure of a higher education learning object, section 3 presents the methodology used to evaluate the proposed metadata structure, section 4 presents evaluation results, section 5 presents the conclusion and future work.

2 METADATA STRUCTURE OF HIGHER EDUCATION REUSABLE LEARNING OBJECTS

2.1 Current Metadata Structure for Higher Education Learning Objects

In the context of this research, we consider a higher education level to be an education level after high school, such as a university. Sun and Williams[11] adopted and extended Cisco’s[10] definition of a RLO in order to “meet the educational requirements for higher education”. Sun and Williams[11] present Cisco Systems Reusable Learning Object(RLO) model [10] as a module of a course in a higher educational institution that is made up of five major components, namely; Reusable Information Object (RIO), Practical object, Assessment object and Summary (see figure 1).
In figure 1 above, the overview of a module gives the general description of the module (such as the module code, the educational level, aim, learning outcomes, among others). The information object is the actual content to be delivered to the learner (these could be more than one depending on the size of the RLO). The assessment object uses a given assessment strategy (embodied in it by the instructional designer) to measure the level of understanding of the learner as far as the content in the RLO is concerned. The practical object in the RLO is optional and can be done offline depending on module requirements[11] and is mainly used to supplement the information objects to enable the learner to practically understand the content in the RIO. The summary is like the overview (in structure) but it is meant to conclude the RLO in form of a review.

In order to formulate the metadata set for a higher education RLO, we analyze the instructional content model by Sun and Williams[11] and we specifically look at the structure of each of the five components of the RLO presented in figure 1. We thus produce a schematic representation of a Higher Education RLO as shown in figure 2.

2.2 Proposed Metadata Structure for Higher Education Learning Objects

As far as the adoption of the definition of a RLO from Sun and Williams[11] by this research is concerned, we further add new metadata elements in the schematic representation (see figure 3). For example, Sun and Williams[11] do not provide identifier element for RIOs yet they show that it is possible to have a RLO with many RIOs (see figure 1 above). It is also possible that a RIO has an external asset file (such as an image, an audio/video file or a code snippet) that is part of content in the RIO. We thus introduce another metadata element on the RIO called asset file that stores information about any external file which could be part of the content of the RIO. We also introduce three metadata elements on the practical object, namely; the identifier (since it is also possible to have many practical objects in one RLO), the target RIO (since each practical is meant for a particular RIO) and the asset file (since it is possible that the practical object also has external files like images and code snippets or Java applets). We further introduce four metadata elements on the assessment object, namely; the identifier, the target RIO since it is possible to have an assessment object per RIO, the assessment question which the learner should answer and also the asset file (since it is possible for an assessment to have an external file). In figure 3 below, the dotted lines indicate the new metadata elements that we are adding to the existing metadata structure in this research, as a way of adapting the higher education learning object metadata structure in Sun and Williams[11].

Fig. 2: A schematic representation of a RLO for higher education according to the instructional content model by Sun and Williams[11].
3 METHODOLOGY FOR EVALUATION OF THE PROPOSED METADATA STRUCTURE FOR HIGHER EDUCATION RLO

3.1 Choice of Methodology for Evaluation

To evaluate the proposed metadata structure of higher education RLOs with multi-format assets, we opted for an evaluation method that allows experimentation of this metadata structure in its prospective environment where we could be passively involved. The justification for this choice was motivated by the need to get feedback from the prospective users who are practitioners in the field of instructional design for higher education course materials. This led us to choose field experimentation method [14] by using a prototype that instantiates the proposed metadata structure. Below we present how this prototype was developed and used in the evaluation process.

3.2 Development of the Tool for Evaluation

We developed a web based tool that can be used to author and adapt RLOs with a metadata structure presented in figure 3 above. This tool is called LOADAPTOR (short for Learning Object Adaptor) and it is currently hosted online as a web based application at www.loadaptor.com. This tool provides a number of functions to guide higher education instructional designers to create and adapt RLOs with multi-format assets. Figure 4 below presents a sample use case for the different actors and their roles when using this tool and figure 5 presents a sample of a RLO under preview in LOADAPTOR tool.
3.3 Evaluation of the Proposed RLO Metadata Structure using LOADAPTOR Tool

To evaluate the proposed metadata structure, we evaluated the functionality, the usability and correctness of the LOADAPTOR tool as far as authoring and adaptation of RLOs (that have the proposed metadata structure) in higher education instructional design is concerned. The choice of these three quality attributes to evaluate the tool was based on suggestions by Hevner et al [15].

We used expert sampling technique [16] to randomly select 8 experts in higher education instructional design from three different universities in Uganda. After analyzing the feedback obtained from these 8 experts, the evaluation process was repeated using a new different sample of 10 experts in instructional design who were randomly selected using the same sampling technique from 5 different universities in Uganda. The results from the two experiments are presented in next section.

4 RESULTS OF EVALUATION

4.1 Results of the First Experiment

Functionality of LOADAPTOR tool. Focus was put on how the tool supports the following functions in higher education instructional design process;

A. Author standard RLOs based on instructional design needs from various stakeholders.
B. Secure the instructional materials designed by the instructional designer through authentication and various access levels.
C. Search the online repository for existing RLOs and reuse such RLOs based on instructional design needs.
D. Create and publish quality instructional content to repositories by allowing public access to only RLOs that have been vetted and approved for publication by subject area experts and instructional design experts.
E. Publish the adapted RLOs to the repository or download them for e-learning environments.

Each of the above system functions (A to E) were rated by the 8 participants of this experiment on a Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Fig. 6 below presents a summary of responses from the participants of this evaluation process.
Usability of the tool. Focus here was on establishing how easily the tool enables the instructional designer to author, adapt and reuse RLOs in higher education instructional design process. To achieve this, the participants of the experiment were requested to rate their agreement with the statement that “the tool is easy to use in authoring, adaptation and reuse of RLOs in higher education instructional design process” based on the Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Out of the 8 experts, 7 (87.5%) strongly agreed to this question, and 1(12.5%) agreed. The rest of the values on this scale had no response.

Correctness of the tool. Focus here was on establishing how the tool correctly instantiates the process of authoring, adaptation and reuse of RLOs in higher education instructional design. This was rated by the participants of this experiment on a scale of Excellent, Very Good, Good, fair, Poor Very Poor and Does Nothing. Out of these 8 experts, 1 expert (12.5%) said that the tool was excellent, 4 experts(50%) said that it was very good, 2 experts(25%) said that it was good and 1 expert(12.5%) said that the tool was fair. The rest of the options under this question had no responses.

In addition, each of the 8 experts was requested to suggest how the tool can be improved and such suggestions were implemented to improve the tool.

4.2 Results of the Second Experiment

When this experiment was repeated with a new sample of 10 instructional designers from 5 different universities in Uganda, we organized a two hours workshop on higher education in instructional design for the 10 participants. They were requested to use the improved LOADAPTOR tool in authoring, adaptation and reuse of RLOs and after, each participant was requested to provide feedback about this tool. The approach used in the first experiment above was also used to get feedback from the participants in this second experiment. Figure 7 below presents a summary of the responses from the 10 instructional designers about the functionality of the tool.

Usability of the tool. As it was done in the first experiment, focus in second experiment was on establishing how easily the tool enables the instructional designer to author, adapt and reuse RLOs in higher education instructional design process. To achieve this, the 10 participants of this experiment were requested to rate their agreement with the statement that “the tool is easy to use in authoring, adaptation and reuse of RLOs in higher education instructional design process” based on a Likert scale of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree. Out of the 10 participants of the
experiment, 4 participants (40%) strongly agreed to this statement, 5 participants (50%) agreed and 1 participant (10%) was not sure if the tool was easy to use. The rest of the values on this scale did not have responses.

**Correctness of the tool.** Still, as it was done in the first experiment, focus was on establishing how the tool correctly instantiates the process of adaptation and reuse of RLOs in higher education instructional design. This was rated by the participants of the experiment on a Likert scale of Excellent, Very Good, Good, fair, Poor, Very Poor and Does Nothing. Out of the 10 participants in this experiment, 7 participants (70%) indicated that the prototype was very good while 3 participants (30%) indicated that the prototype was good as far as adaptation and reuse of RLOs in higher education instructional design process is concerned. The rest of the values on this scale did not have responses.

The results from the two experiments showed a strong positive correlation and this proved that the proposed RLO metadata structure can be adopted by higher education institutions in instructional design process to create RLOs for their e-learning environments. Using such an enhanced metadata structure helps to improve on the reusability of the RLOs developed.

**5 CONCLUSION AND FUTURE WORK**

This paper focused on proposing a metadata structure for a higher education RLO. This was achieved by adaptation of existing RLO metadata standards through extension of the metadata sets. The extensions that were added aimed at improving adaptability of such RLOs with multi-format assets. The two experiments done to evaluate the proposed metadata structure for higher education RLO showed a strong positive correlation which proved that the proposed RLO metadata structure can be used to author, adapt and reuse RLOs in higher education instructional design.

Future will focus on measuring the learnability of the instructional content created using RLOs with such a metadata structure in higher education institutions.

**REFERENCES**

Design Model for Constructivist Learning. Association for the Advancement of Computing in Education (AACE), Switzerland, 2004


Issues of E-Learning Search Engine and its Challenges

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ABSTRACT

Search engines have enough benefits in many fields such as business, trade, health, tourism and so on. In the e-learning systems search engines can be applied to the regular teaching and education, higher education, initial and continuing training. Given the issues and challenges of e-learning search engine, students, teachers, administration, and other participants may finding themselves in a position in which they can further develop this type of search. This paper presents the opportunities of search engines; however, the attention will be on issues and challenges related to e-learning search engine and their characteristics that we have deducted following an interesting selection method of papers, an analysis and a precise comparison between the benefits and challenges of search engine-based e-learning with their difficulties. Thus, we proposed several suggestions and eventually a policy to be taken into consideration by educational institutions to make these engines more efficient. This paper will lead an important overview of the progress of search engine-based e-learning for the educational institutions.

KEYWORDS

search engine, e-learning, issues, challenges, policy, educational institutions.

1 INTRODUCTION

The search engines are concerned in finding from a large corpus, relevant documents (image, text, video, web page etc), responding to the user's request. It’s the name of search systems in the advanced computer field and in information management, their profits interact with other fields. Search engines are a whole of technics that provides access to relevant information. Search engines currently use indexing and searching techniques to find pertinent documents. In practice is the development of directories with more advanced and more intelligent systems to increase search performance. Robust search engines help in finding, sharing, merging documents using local networks, cloud computing and internet tools.

The e-learning systems also interact with educational applications of search engines, these applications help e-learning actors (students, teachers, administration, and other participants) to annotate, find and use learning object (LO) [1], [2]. This interface provides several benefits in e-learning systems such as search of information from courses, the sharing between actors, searching guided by assistance, minimize the time of the preparation of indexing and the outputting of knowledge’s searching models [3].
The challenges and issues are one of the major concerns for performance or arrears of search engines baptized by the automation technology of information processing. Search, explore, reuse, annotate, assist is the wonderful gift of e-learning search engines, but the problem is that these benefits have enough challenges to shape either in the metadata, semantic search, reusing and searching by assistant. Other difficulties such as interoperability, automation, hidden and multimedia LO influencing the performance of the usage and exploitation of e-learning actors.

Thereby, the main purposes and objectives of this paper include:
- Examine the search engines and their benefits.
- Discover the e-learning search engines their issues and challenges; Evince several effective examples.
- Get research findings.
- Propose suggestions and policy.

The next section presents significance and benefits of search engines in general and in e-learning systems; thereafter is the section that explains the method used to select the papers cited in this paper; this section is followed by benefits, difficulties, challenges of e-learning search engines as well as findings, suggestions and finally there is conclusion.

2 SIGNIFICANCE AND BENEFITS OF SEARCH ENGINES

The search for the information dates to 1948 [5]. Mooers worked on this subject for the first time in his master's thesis. Several definitions of search information have been defined [3], [6], [7], [8], [9], [10], [11], [12] to describe the search as a process of how information is deposited, ordered, characterized and easily available to the user. This topic has assumed great importance in the scientific community, it yielded several impressive results [13], [14], [15]. Figure 1 shows several advantages of search engines that help examiners humans to quickly identify where find the interest information; represent the document (respectively the request); help users find and use information effectively; provide multiple indexing models (manual, automatic); provide access to lots of information and make precise searches (using boolean operators, truncation etc) with ergonomic interfaces and an ease of use; rank results; find the correct meaning of each word in the document (respectively the request); match the need for information with those of the database.

**Figure 1. Benefits of Search Engine**

Most learners use general search engines including several varied disciplines to find LO related to their studies, but it seems less useful because of the time and effort that students must spend to find items related to their learning requirements and favorites. Universal search cannot and probably should not meet the precise needs of disciplines [16] the need for enhancement is an important challenge in this case [17].

As shown in figure 2, the e-learning systems interact with educational applications of search engines to overcome the boundaries of the general search.
In the case of e-learning systems the search engines used are inspired by exploratory learning approach [4] which allows students according to search and indexing mechanisms to direct their own scholarship. Through the process of discovery, or guided discovery thereby the student learns the facts, concepts, and procedures. E-learning search engines offer many profits, but it offers so many difficulties and interrogations that are critical to support.

3 THE RESEARCH METHOD

Since their commencement, search engine-based e-learning have been extensively studied by researchers. Considering the massive number of papers existing, it was decided to reference a sample of the significant literature in this paper. Most papers were selected for study if they were relevant, using some questions as criteria for inclusion or exclusion:

- Is the search engine compatible with e-learning technology?
- Was the article published recently or formerly?
- Is the setting are pertinent for the efficacy of search engine and e-learning for educational institutions?
- Do the researchers present enough background, are the results replicated?
- Is the article interesting in the field of search engine and e-learning research?

Thereby, papers that are supported, are from recognized scientific databases. We have selected papers published in recognized proceeding of international conferences and in recognized international journals. For dates of publications we tried to be opened on the old and recent publications, to provide a rich and comprehensive study, knowing that the old publications contain the fundamentals of science and recent publications contains the latest results and advancement of technology.

After the selection of papers, the most important features of educational search engines are divided into two parts. the first part contains the benefits plus challenges, and the second contains the difficulties. Other features that relate more to learning management systems (LMS) are not covered in these parts such as technical, infrastructure, platform and service aspects such as IT security and other characteristics.

We then compared the benefits of search engine-based e-learning with their difficulties following tables that will be presented after to getting research findings and propose solutions.

4 BENEFITS AND CHALLENGES OF E-LEARNING SEARCH ENGINES

The search engine provides several benefits in e-learning by using metadata [18], semantic indexing [19], reusing and search by assistant technologies. With the help of search engines, the searching and exploration of LO is easier, aspects such as assisting, navigation, sharing, reusing, and adapting of LO is also possible. However, there are still challenges to overcome to make these engines more efficient.
4.1 Metadata

Today metadata standards [20], [21] allow indexing, location and reusing of LO. An exploratory study was conducted by [22] reveals that the LOM-base search offers plenty of opportunities and a real advantage over search based on the resource’s content. Another example explains how actual software systems apply these metadata to simplify the location of LO, especially in the case of the brokerage service for LO [23].

In addition to the previously cited features, some e-learning systems permit navigation of their collections but there are others who are unable to organize a course tailored to the specific learners, because relationships between all LO are not clearly defined and the real goals of the users are difficult to recognize. The case study of [24] affirm that interfaces that have good definitions of these terms of usability, have proven a great advantage for the location of LO within the navigation scheme, and therefore have allowed us to know the classified structure to continue with the exploration process.

Another challenge could come from these standards is that they focus much on the technical aspect and neglect the educational information related to the real use of LO in the context [25].

The automation of metadata generation is an important advantage for e-learning systems. Search engines index LO automatically without manual intervention of the users, making metadata generation easier in a shorter time. In this context, the system proposed by [26] allowing the automatic extraction of semantic metadata from a specific sub-set of LOM metadata.

The challenge of this kind of systems is the quality of the annotation, sometimes the manual value is better, sometimes the automatic value is better [27]. Automatic generation of pertinent metadata for LO is still a very difficult problem, and currently a hot topic. The fact that the related educational information depends in large extension on the context and the information generated automatically fill only the simple fields who have low value.

4.2 Reusing

Support adapting and fragmentation of LO is another advantage for search engines. A LO is an entity that we can find, share, reuse, and adapt it in a learning process assured by technology [28], [29]. According to Wiley [30], with small units of LO well indexed, we can lead to a faster and more efficient creation of new LO. The main objective of creating learning objects is to build fragments of course or small parts that can be used and reused in different learning contexts. For example [31] presents KnowledgeTree, an architecture for adaptive e-learning based on distributed reusable intelligent learning activities. It provides answer content queries – listing search results: activities that match a specific description (in terms of metadata) or provide all known metadata for a specific activity. It provides also the ability to launch an activity by direct request. Therefore, we reduce the production cost of LO and the expertise to produce it.

The challenge of this system is the need to find an agreement on what constitutes exactly an LO. There are many definitions, some so large they consider LO as anything at all [32]. In the broadest sense, a learning object is anything that has an educational purpose [33]. In this case it necessary to find, analyse and refine LO manually before reusing it, what will generate enough worries.

4.3 Semantic

More importantly, semantic search engines overcome the problems that have been posed by classical search engines [34]. Two major benefits of this transformation; the first is that the LO presented in search results have a semantic relationship with the requirement.

We will mention three cases which have been able to affirm this statement [35], [36], [37]. These search engines are well evaluated according to the precision, recall and f-measure measurements. The second benefit is
the deduction of the appropriate semantic context for the search [38]. However, two major challenges facing this type of search engine; the first is that the studies of usability of these search services reveal that are not easy to use [39]. The second challenge is that the reasoning modules based on the inference engine technologies may not be valid in all potential uses [40].

4.4 Assistant

The last advantage that will be cited is the search engines by assistant that presents a user-friendly interface to guide the user in the description of the LO and provides other useful features such as the advanced search, automatic translation of terms, recommendation of terms, reduction the time of search, grouping of search results, follow students, implementation of many visual and cognitive aids, detection of misconceptions and the proposal of LO to overcome them. According to search assistant proposed by [32] success in finding learning objects by study participants went from 80% using Google alone to 96% when using their search assistant in one scenario and, in another scenario, from a 40% success rate with Google alone to 66% with their assistant.

It is important to note that users tend to have difficulty to choosing the proper keywords [41]. Help users to find relevant LO is an area that needs more attention. The importance of such encouragement becomes clear in e-learning [42]. Search engines should be simple and smart enough to detect the favorites and requirements of students [43], [44], [45].

5 DIFFICULTIES OF E-LEARNING SEARCH ENGINES

It is important to note that an increasing difficulty appeared to search, manage, and classify LO for an e-learning environment [46]. Among the main factors influencing the performance of these engines there is the concern of indexing and searching interoperability, manually indexing, searching of hidden LO, indexing and searching of multimedia LO.

5.1 Interoperability

For the difficulties, we start with interoperability which refers to the implementation of LO in different learning and content management systems and how to plug and play it easily in different platforms. Interoperability is defined as the creation of a semantically compatible information environment based on the agreed concepts between different entities [47]. Providing interoperability among heterogeneous e-learning systems is one of the main issues in creating a distributed e-learning systems and federated e-learning systems. This difficulty is due to the technical difference between these systems, the difference exists in the indexing and searching methods especially when trying to determine semantic meaning: The same data value can have different meanings from one e-learning system to another. Although [48] identified the interoperability gap that exists between Learning Object Repository (LOR) and Learning Management System (LMS), there remained many unanswered queries by their search. Another issue which concerns interoperability between e-learning systems is that have heterogeneous interfaces that are not easy to use [48], [49] aptly observed, “It is clear that some sort of interface between the two components (LMS & LOR) is required to enable a system to benefit from the other one.” [50] define the problem in two points; the first problem of the LO paradigm is the incoherence in the medatada. This incoherence is due to the fact that the labelling process, which is basically done by hand, generates documents with serious shortcomings, including many deficiencies related to the lack of key attributes in the description. This makes it difficult, or impossible in some cases, to study this aspect. The second problem is the heterogeneity of the repositories and their malfunction. The proposed system by [50] tries to minimize this second problem.
5.2 Manually

We now turn to the manual generation of reliable metadata that still a very difficult problem and is currently a hot topic in the Web 2.0 movement. In many learning management systems, metadata can be associated with learning objects manually, or they can be generated partially by the system. Manual creation of metadata might be feasible in small deployments, but that it is not an option for larger deployments where a considerable number of LO must be managed for each user. The system should offer functions comparable to search engines and classifiers for the web. Search engines must index LO automatically without manual intervention of the users or the creators of the LO [27].

5.3 Hidden LO

For the penultimate inconvenience, it is the hidden LO. There is a large mass of LO in e-learning systems unreachable by the available search engines. These LO are called hidden, deep, or invisible opposite to LO found in the search engines available. The techniques developed for conventional search engines are very effective in the search for visible LO. The method of crawling used by search engine uses a centralized discovery technique that can be applied to LO visible by crawlers. This technique cannot be applied in a deep environment where LO are accessible by techniques adapted to specific sources. However, some e-learning systems can be difficult to find and share their LO, while others are not available to the public. Also, e-learning systems has a challenge to retrieve LO; an example would be LO that is stored in LOR databases [51] or search engine that place LO that is irrelevant for the educational topic ahead of the relevant LO, the LOs become hidden or not easily discoverable.

5.4 Multimedia

The last difficulty that will be cited is the Multimedia LO. Regarding the multimedia indexing is often treated as the inverse of the creation process. A film is based on the actions of the writer, director or editor who are guided by the need to create a narrative and physical characteristic of the media used. This structural approach is basically developed to offer search applications by content. These descriptions are not only a way to attach information to different levels of audio-visual document contents, but they also help define organizational structures of the documents on which applications can be rest on. However, the metadata generated for Multimedia LO cannot be effective for semantic search engines. The work proposed by [52] describe and evaluate a new approach to generate a semantic annotation for multimedia resources; unfortunately, the quality of the annotation is not as good as if it were done by a human.

6 FINDINGS AND SUGGESTIONS

So far, there has been a significant literature on e-learning search engines. In this section we will summarize them in two tables to abstract, analyze and compare the benefits and difficulties of these engines. The first table (table 1) contains the benefits offered by e-learning search engines. Firstly, it gives the advantages offered by metadata to improve indexing, location and reusing of LO [22], [23], enabling navigation [24], creating relationships between LO [20] and automatization of indexing [26]. Secondly, it gives the advantages offered by the reutilization like support adapting [28] and the capacity of course's fragmentation [31]. Thirdly, it gives the advantages offered by semantics such as improving semantic search engines [35], [36], [37] and the capacity of reasoning [38] and in the end it gives the advantages offered by the assistant that help users to find LO [32], [42] and to detect the preferences and needs of students [43], [44], [45]. The second table (table 2) contains the difficulties posed by e-learning search
engines. In the first place, it gives the difficulty of interoperability especially between federated e-learning systems that has difficulties to support technical heterogeneity [47], [48], [49], [50]. Secondly it gives the problem of manual indexing and that enormous efforts are needed for obtaining great value [27]. Thirdly there is the difficulty of hidden LO and that E-learning systems has a challenge to retrieve Hidden LO [51] and finally it gives the problem of multimedia LO because the quality of the generated Metadata is not as good as if it were done by a human [52].

By analyzing prior research on this technology, we can compare the benefits of e-learning search engine [20], [22], [23], [24], [26], [28], [31], [32], [35], [36], [37], [38], [42], [43], [44], [45] as shown in table 1 with their difficulties [27], [47], [48], [49], [50], [51], [52] as shown in table 2 as well as getting research findings and propose solutions.

Table 1. Summary of E-Learning Search Engine Benefits

<table>
<thead>
<tr>
<th>Benefits</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metadata [18]</td>
<td></td>
</tr>
<tr>
<td>Improve indexing, location and reusing of LO</td>
<td>[22], [23].</td>
</tr>
<tr>
<td>Enables navigation</td>
<td>[24].</td>
</tr>
<tr>
<td>Creates relationships between LO</td>
<td>[20].</td>
</tr>
<tr>
<td>Automatization</td>
<td>[26].</td>
</tr>
<tr>
<td>Reusing</td>
<td></td>
</tr>
<tr>
<td>Support adapting</td>
<td>[28].</td>
</tr>
</tbody>
</table>

Table 2. Summary of E-Learning Search Engine Difficulties

<table>
<thead>
<tr>
<th>Difficulties</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interoperability</td>
<td>[47], [48], [49], [50].</td>
</tr>
<tr>
<td>Manually</td>
<td>[27].</td>
</tr>
<tr>
<td>Hidden LO</td>
<td>[51].</td>
</tr>
</tbody>
</table>

Enables fragmentation of course [31].

Semantic [19]

Improve semantic search engines [35], [36], [37].

Enable reasoning [38].

Assistant

Help users to find LO [32], [42].

Detect the preferences and needs of students [43], [44], [45].
Multimedia

The quality of the generated Metadata is not as good as if it were done by a human [52].

Search engines bring several benefits to e-learning systems, but at the same time face enormous difficulties and shortcomings hindering their development which adversely affect the performance of e-learning actors. By focusing on the positive and negative points and filtering what we found, we could draw some ideas to achieve optimal coupling search engine and e-learning.

6.1 Findings

Several benefits, difficulties and challenges could be found; which will be summarized in the following.

The search engine provides several benefits in e-learning by using metadata, semantic indexing, reusing and searching by assistant technologies. However, there are still difficulties and challenges to overcome. For example, metadata focus much on the technical aspect and neglect the educational information related to the real use of LO in the context [25]. Also, the metadata generated for Multimedia LO cannot be effective for semantic search engines [52]. Metadata creation is another difficulty; the manual creation of metadata demands high effort for obtaining great value otherwise automatic indexing of LO fills only the simple fields that do not have great value to add [27].

On the other hand; some e-learning systems can be difficult to find and share their LO thus the LOs become hidden or not easily discoverable [51] and the reasoning modules based on the inference engine technologies may not be valid in all potential uses [40]. Better search and reuse of LO reduces the production cost and the expertise to produce it, the challenge of this system is the need to find an agreement on what constitutes exactly an LO [30]. On another side, distributed e-learning systems suffer of enough worry such as interoperability [47], [48], [49], [50]. Additionally, general search cannot and probably should not meet the specific needs of disciplines [16]. Success / relevance of search occurs when the intelligence of the questioner of search engine match the intelligence of those who designed it and when the assistants search increasing the level of help and navigation between LO and reduce the number of returned LO [32], [42].

6.2 Suggestions

Instead of a classical or general search which includes enough disciplines diversified; e-learning actors should go for specialized searching; integration of knowledge and domain of understanding is essential in the recovering, indexing, presentation, searching, classification and reusing of LO. For example, educational institutions can develop search engines dedicated to LO and encourage their e-learning actors to use it instead of the classic or general search engines that appears in the Web. In the literature, there is enough technique of metadata, semantic indexing, semantic searching and reusing of LO. Each educational institution can adopt a technique as required.

Concerning the deduction and the reasoning on LO; is a very interesting topic deserves further examination and research. The educational institutions can take into consideration these techniques the deduction allows us to detect the appropriate semantic context for the search to involve the users. The educational institutions must be careful in the choice of technique since the reasoning modules based on the inference engine technologies may not be valid in all potential uses. Otherwise must propose their own techniques.

Another suggestion is that the assistants search need leverage the description of the LO to arrive to queries that provide accurate search results. There are several assistance techniques for search engines. The educational institutions can adopt these assistance techniques to make search simpler and more efficient; For example, can begin with the proposal of the user-friendly interface to guide the user in the description
and the search of the LO, and subsequently accompany this step by automatic translation of terms, suggestion of terms, reduction the searching time, grouping of search results, follow students, implementation of many visual and cognitive aids.

For unification of the indexing, searching, reusing approaches for standardize the field of e-learning search engines need be introduced. For example, educational institutions can go for national and regional federated e-learning systems while maintaining interoperability and availability of LO to integrate.

For the latest suggestion; instead of manual method, automate the indexing of LO, especially multimedia LO, appeared to be the successor of the manual one; a new document automatically indexed, will be searchable and verifiable with a minimum of work. But what appears is that sometimes the automatic value is not better than manual and in most cases the information generated automatically fill only the simple fields who have low value. Educational institutions can benefit of advantages of automatic indexing techniques. So, it is necessary to think of a compromise between manual and automatic indexing which can be for example the techniques of semi-automatic indexing.

Educational institutions can benefit from the different recommendations which are mentioned before and prepare a policy specific to their context. But in general, we suggest a policy as follows:

- Adopt automatic and hybrid indexing, combining and benefiting from different techniques, classical, semantic and by metadata [18] [19] [26].
- Adopt methods of interoperability within the institute and with other partner institutes [50].
- Adopt exploratory search methods [53].

According to the different comparisons that are made, the issues and challenges elevated; the careful adoption of this policy will give a lot of progress to the search engines of the educational institutes.

7 CONCLUSION

This paper presented issues and challenges related to e-learning search engine. This last offer many benefits, but it offers so many difficulties and questions that are critical to support in the future research. E-learning may also benefit from search engines that provide many opportunities and plays an important role for overall IT infrastructure development. Searching, exploring, reusing, annotating, assisting is the wonderful gift of search engines. These benefits have enough challenges to shape either in the metadata, semantic searching, reusing and searching by assistant. However, these search engines still have enormous difficulties such as interoperability, automation, hidden and multimedia LO influencing the performance of the use and exploitation of e-learning actors whether students, teachers, administration, and other stakeholders. At the end of this article we proposed several suggestions as well as a policy to remedy these various difficulties. There are still some limitations in this study which will be dealt in the next studies, we quote for example the lack of issues and challenges of the technical aspects of implementation of these e-learning search engines. We quote also the deep relationship between these engines with LMS and other aspects such as cloud computing, big data, IT security.

REFERENCES

Wide Web conference on Alternate track papers & posters (pp. 104-113). ACM.
Mathematics with Using Information and Communication Technology

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ABSTRACT

Mathematics has an irreplaceable function in human life. Pupils and students at primary, secondary schools and universities have a non-adequate attitude to mathematics. Their imaginations and attitudes are on the scale from high admiration to rejection of mathematics as such. We suppose that the problem is not in mathematics itself but in the way and art of its teaching. In spite of many doubts about its usefulness, many application tasks indicate the fact that without mathematics we would not be able to solve many simple life situations.

Using ICT in mathematics education can help by the solving of these topics.

KEYWORDS

Information and communication technologies (ICT), mathematics education, GeoGebra, Matlab, content reform, real-life problems in education, Slovak National Curriculum ISCED 1, 2 and 3.

1 MATHEMATICS EDUCATION AND ICT

According Lamanauskas in [1] new technologies consistently and rather aggressively have strong influence to the educational practice. It brings emerging challenges both for teachers, students in every type of schools and also in teacher training at universities.

We can identify at least three reasons for promoting the integration of Information and Communication Technologies (ICT) in Mathematics teaching in schools (see [2]):

a) Desirability: The use of ICT stimulate motivation of students and curiosity; encourage and motivate them to develop their problem-solving strategies. The use of ICT may improve efficiency of teachers educational activities, release more time to address students individually, stimulate re-thinking their approach to teaching and understanding.
b) Inevitability: Many fields of publishing have moved from printing to electronic form. This applies to conference proceedings, reference works such as encyclopaedias, webpages, online applications, small-circulation textbooks, special journals, different kinds of tubes etc.
c) Public policy: There is defined in Slovak National Curriculum ISCED 1, 2 and 3 that mathematics as a subject belongs to the group “mathematics and working with information”.

Important aspect of ICT aided education is the visualization. It can bring for mathematics education:

• Effective approach while discovering the results, solving problems and using different kinds of models for the solution of the problem,
• Visualization of relations and functional connections in one model allows to deduce new results in other areas and fields of mathematics and other subjects,
• Supporting of mathematical competence and basic competences in science and technology; digital competence; learning to learn.

The method of generating problems (see [3]) seems to be suitable for this kind of teaching (due to its systematically creating sets of internally connected problems). Student’s activities and instructions have to be regarded as complementary factors in the educational process. These factors both are necessary and must be systematically related to one another so that optimal progress can go forward. The aim of our method is to create areas in which the students may–using the result of guided teaching–move as independently as possible, and in which students develop their own initiatives, activities and own kind of thinking. Students are considering their
own problem and they could ask for help as far as it is necessary. By this way they obtain basis for further work. After a problem has been completely solved and clarified the teacher together with students is thinking about continuation of the problem and generate problems which are related to the problem just solved. Thus the original problem acts as a generating problem; we will call it generator problem (GP). Related problems are obtained by analogy, variation, generalization, induction and deduction etc. The group of all new problems together with their GP will be called the set of generated problems of the GP or the problem domain of GP.

2 THEMATIC AREA GEOMETRY AND MEASUREMENT IN UPGRADING STATE EDUCATION PROGRAM ISCED1

Since 2014 Slovak curriculum for mathematics education for primary level in the State Educational Program ISCED1 has been complemented by an innovative program with performance standards for various thematic areas and various school years. We will focus now to the thematic area “Geometry and measurement”. In the first year, the teaching process focused on planar geometric shapes: curved line, straight line, open and closed line, circle, square, triangle, rectangle (see [4]). As for the three-dimensional structure, cube, cylinder, and sphere were recommended. Over this year, pupils learn to have orientation in plane and space (right, left, up, down, over, under, in, on, in the front of, behind, beside, between, in the front, in the back). Units of length are taught only on an intuitive level, taking advantage of both historical units (foot, thumb, palm, elbow, another subject – e.g. clip), and comparing dimensional geometric figures (longer, shorter, higher, lower, wider, narrower, longest, shortest, lowest). On propaedeutic level, the pupils are acquainted with identical display - axial symmetry.

In the second year, students already get to know the basic geometric objects - point, line, ray, line segment, point belongs (do not belong) to the formation, the point lies (do not lie) on the formation, the endpoints of the line segment. Over this school year, the standard units are introduced: millimeter (mm), centimeter (cm), meter (m) and the length of the line segment in centimeters is determined. Comparison and arrangement of line segments is realized by a strip of paper, measurements and estimates, and are also used instruments for measuring length: ruler, meter, measuring tape. At a propaedeutic level, the pupils are acquainted with identical display - slide. They learn to name polygons: a triangle, quadrilateral and so on and identify their sides and vertices.

In the third year, students determine the length of line segment or dimensions of geometric shapes in decimeters and kilometers. Great attention is paid to the drawing basics: purity and precision of drawing, choice of suitable drawing equipment, hygiene and safety at drawing. In the area of plane figures, the square grid begins to be used: drawing a square and a rectangle in the square grid, marking the tops of square and rectangular by block capitals, zoom in and out of plane figures in a square grid. On propaedeutic level, pupils get to similar structures. In the three-dimensional structure, pupils become familiar with vertices, edges and sides of the cube. They form the building from cubes, the plan of building from cubes (plan structure with the indicated number of cubes standing on each other), rows and columns (for buildings from cubes).

In the fourth year, the students learn to convert the unit of length (mm, cm, dm, m, and km), mixed unit of an example of 1 m 10 cm. In the area of plane figures, attention is paid to drawing triangle and polygon - vertices, side, diagonal, opposite and adjacent sides, number of sides and vertices, length of adjacent and opposite sides. Here students will meet with the first construction tasks: drawing any triangle, drawing triangle if the lengths of its sides, the sum and difference of the lengths of line segments are known. Next topics are multiple of side length, circumference of square, rectangle and triangle as the sum of the side length at the propaedeutic level.

In addition to these geometric figures, pupils learnt to basic knowledge about the circle, circular line and how they can be drawn by drawing compasses.

The curriculum recommend to use manipulatives and models, some of them is possible to prepare with the educational software. Figure 1 shows shapes, which are possible to prepare with game “Tangram” with software GeoGebra.
It is possible to prepare following figures (see Figure 2 and Figure 3).

3 MATHEMATICS IN REAL LIFE

Mathematics accompanies us in everyday situations. There exist many abstract mathematical theories, which have later many applications. According to Lobachevski (see in [5]): “Each part of mathematics, however abstract it is, will find its model in real life one day.” One concrete example is using Lobachevski theory of non-Euclidean geometry in Einstein’s general theory of relativity. But many simple every-day situations is possible to solve with help of mathematic methods. These real-life problems are suitable for school mathematics.

For example, withdrawing money from a bank machine would be impossible without Carl Friedrich Gauss (see [6]). Entering the PIN code in the terminal has to be encoded and subsequently decoded with the help of computer. This action is not possible without coding whose mathematical basis is in the theory of numbers. Mathematics teaches students how to think logically, how to look for the combinations when solving problems. It also teaches us to be accurate. Despite this fact, many people consider mathematics to be their lifelong problem.

Primary, secondary as well as university teachers of mathematics frequently have problem to find mathematical applications in everyday life. This question is especially surprising when the university students meet interesting problem solved by visible mathematic method. They should be clear about the importance of mathematics when they choose to continue in their studies of mathematics at the university. Therefore, to motivate students to study mathematics has become a difficult task for many teachers at every kind of school.
They should know how to bring fun and enlightenment of mathematics to the class. Therefore, it is necessary to prepare future teachers of mathematics to teach pupils to discover the beauty of mathematics in everyday-life (for example in [7]). Application tasks serve as a good place, where the confrontations between a human and mathematics are predominantly realized. We can see the application of geometry everywhere, for example geometric patterns on mosaic pavements of European temples. When we look at some fabrics, we also find various geometric shapes – e.g. triangle, square, rectangle or circle. We can observe mirror reflection and look for similar shapes and axes of symmetry. We observe in many areas of our life an interesting mathematical object – a spiral. A group of congruent right-angled blocks forms the spiral. They are joined together longwise and truncated by the plane breadthwise. The plane has an intersection with just one edge of the block or it goes just through one of its vertices. The geometry is just the right topic when it is appropriate to use some suitable mathematical software to improve imagination in pupils. Do our pupils have a good imagination? Are they sufficiently prepared to understand the importance of geometry in practice? The answer is negative. Even students, future teachers of mathematics, have a problem with imagination. One of the reasons is the educational reform that began in 2008. Therefore, it is important and necessary to prepare future teachers of mathematics to teach pupils to discover the beauty of mathematics in our lives.

4 MATHEMATICS IN THE NEW CURRICULUM IN SLOVAKIA

Since 1 September 2008 the Content Reform of Education in Slovakia has been being implemented in accordance with the Act No. 245/2008 on education and training and on amendments and supplements to certain laws approved by Slovakian Parliament on 22nd May 2008 which replaced the original so-called Education Act of 1984. The Content Reform of Education means not only changing of the curriculum content, but also transformation of methods, conditions, forms and manners of education as well as its time organization associated predominantly with a teacher, and financial and legislative changes and sequence of steps.

Every school must prepare his own school educational program. Schools have the responsibility to adapt their specific school educational programs in the range of approximately 30%. That means that in 70% they must respect the State Educational Program. Compulsory content of education and training at schools are defined and specified by the state educational programs. The respective educational program represents a standard for schools but also an aid in the formation of the schools education and training programs. General education program should have replaced current curricula, and educational standards for primary and secondary schools. It should have become a mandatory pedagogical document. After the introduction of the State Educational Program ISCED 2, the number of lessons in individual subjects is determined by the framework curriculum. The content of education was divided into the following educational areas: language and communication, mathematics and working with information, man and nature, man and society, art and culture, man and values, man and the world of work, and health and exercise. The basic structure of the content of education was based on the key competences defined by the expert group of the OECD in the frame of the project DeSeCo (the acronym of Definition and Selection of Competencies: Theoretical and Conceptual Foundations, see http://deseco.ch/). It corresponds to modern trends used in many developed countries. The success of the transformations in education depends on the fact how the reform of education and training will be accepted by teachers, school leaders and parents, and what importance will be assigned to the education and training by society. New resources can be beneficial for improving teaching and schools (see [8]). However, a good teacher remains a decisive factor in the reform. "Pedagogical work stands and falls on the motivation and skills of teachers. Innovation helpfulness and professionalism must be based on the qualitative new forms of education and training of teachers" (see [9]).

We present in the following tables changes in the geometry curricula during the period 1997-2011:
Table 1. Mathematics at lower secondary level from the school year 1997/1998.

<table>
<thead>
<tr>
<th>Year of study</th>
<th>Number of hours per week / per year</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5/165</td>
<td>angles, triangles, constructions of triangle</td>
</tr>
<tr>
<td>6</td>
<td>5/165</td>
<td>parallelograms, trapezium</td>
</tr>
<tr>
<td>7</td>
<td>5/165</td>
<td>circle, axial symmetry, central symmetry, congruence, similarity, volume and surface of cone and pyramid, constructions tasks</td>
</tr>
<tr>
<td>8</td>
<td>5/165</td>
<td>translation, homothety, dilatation, constructions tasks, goniometry of acute angle</td>
</tr>
<tr>
<td>9</td>
<td>5/165</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Mathematics at lower secondary level from the school year 2003/2004.

<table>
<thead>
<tr>
<th>Year of study</th>
<th>Number of hours per week / per year</th>
<th>Geometry</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>5/165</td>
<td>angles, triangles, constructions of triangle</td>
</tr>
<tr>
<td>6</td>
<td>4/132</td>
<td>perimeter and area of a square and rectangle</td>
</tr>
<tr>
<td>7</td>
<td>3.5/115</td>
<td>axial symmetry, triangle, parallelograms, prisms</td>
</tr>
<tr>
<td>8</td>
<td>4/132</td>
<td>trapezium, congruent mappings</td>
</tr>
<tr>
<td>9</td>
<td>4/132</td>
<td>circle, axial and central symmetry, similarity of geometry objects</td>
</tr>
</tbody>
</table>

For example, the increased number of lessons for foreign languages, or the creation of new subjects, had the effect of reducing the number of lessons in the subjects of natural science. We as teachers obtain now actual question: In which conditions can we create sufficient time space so that we can efficiently prepare our pupils for life? Since 2008, there are not precisely defined lesson subsidies of subjects for each class. In 1997 curriculum, approximately 200 lessons were allotted to geometry in the 5th to 9th grades. In the new curriculum (2010), there are about 170 geometry lessons in these grades. It means about a 15 percent decrease as compared to the previous number. It is important according [10] to note that within the meaning of the school law, the number of lessons is defined only for the whole stage of education and not according to grades, as it was in the old curriculum.

The number of lessons in each class is managed by the schools themselves. Although we are aware that the framework curriculum is a living document that need adaption to the conditions, we think, that too frequent changes help not students. The teachers of secondary schools claim the same, when presenting, they have to reduce their
claims to the students in the course of two decades nearly by 30%. As we mentioned above, State education programme prescribes the compulsory subjects, which are included in various educational areas. These include according [11] the previously mentioned areas of mathematics and working with information and communication.

Mathematics education is not an independent component of the education. Mathematics undoubtedly develops cognition of each pupil, and through its methods and means, is destined to become a tool for the development of the functions of distributing knowledge (see [12]). Most of the technical amenities have its roots in mathematical theories. In spite of these facts, mathematics still ranks among the least favourite and unattractive subjects for pupils. Let us ask the question: Why is it so?

It is generally known that mathematics is rather unpopular and less interesting subject for pupils at primary schools. Today's pupils are used to sitting in front of the TV and listening opinions on mathematics, which are presented by famous media people. These people often do not have a problem, or even a courage to express their uncaring attitude to mathematics in public. Moreover, pupils are listening to these opinions from their parents. Due to their little experience, they are not always able process correctly this information.

On the other hand, we have to say that the teachers who are unqualified often teach mathematics at the lower secondary level. The quality of teachers and their work has a direct impact on pupils’ way of learning, their attitudes towards learning, on their knowledge, as well as on their motivation to learn. The students need to have qualified teachers. What is the reason for their absence?

Teachers, who are currently teaching, especially at primary schools, could be separated into two groups:

a) some of them are convinced that their work has meaning and purpose and try to pass on their knowledge and understanding to students as much as possible,

b) the others who could not find work in field of their interest or they have some other reasons.

The second group of teachers is one of the reasons why there is a negative situation in teaching mathematics at primary schools.

But at the same time we must remember that today’s teachers need to develop and complement their education constantly if they want to understand an educational process and also their pupils. Therefore a teacher is expected to use information and communication technologies as didactic devices in their everyday educational, training and teaching process.

5 BORDERS IN USING ICT IN MATHEMATICS EDUCATION

Students with reduced curricula in mathematics education in the secondary school, are not able to choose suitable scale for drawing graphs.

It is good visible in the task, in which they are asked to identify some kinds of functional properties. We have experiences in following examples:

We start with the concept of derivative. Let we have a function

\[ f(x) = x^2 + 0.8|x-2| + 0.5. \]

![Figure 3. The function f: The graph drawn with educational program, which look like such a function, which has a derivative at every point](image)

![Figure 4. The Function f: The derivative at the point 2 doesn’t exist](image)
Figures 3 and 4 show that visual representation of some properties of the function depends from the scale by the drawing graph of the function. The second example for this fact is the function 
\[ g(x) = x^4 - 0.02x^2 + 1. \]
The wrong scale show us the wrong number of extrema (see Figure 5 and 6).

![Figure 5](image)
The function \( g(x) \): three extrema are not visible.

![Figure 6](image)
The function \( g(x) \): three extrema are good visible.

We continue with the question of continuity of the function. Let we have a function
\[ h(x) = \frac{\sin x}{x}. \]
This function has a limit at the point 0 with value 1 (see also Figure 7).

![Figure 7](image)
The limit of the function \( h(x) \), which is calculate with GeoGeBra CAS

\[ \lim_{x \to 0} h(x) = 1. \]

This result is difficult to understand for students.

![Figure 8](image)
Figure 8. The function \( h(x) \), which is not defined at the point \( C \) and with some chosen point \( A \). Function \( h(x) \) is defined at the point \( A \).

We mark the point \( C \) with the marker circle. The function \( h(x) \) is undefined at the point \( C \) (see Figure 8).

We repeated these tasks with the software MATLAB. We compare our results.

### 6 GEOMETRY EDUCATION AND MATLAB

As we know it’s very important to find answer to the question: “How to teach mathematics as such?” At this time it’s already clear that teaching of mathematics should be changed. Modernisation of an educational process includes not only the change of teaching methods and forms but first of all the change of the work style and approach to students. These process would be impossible without the teacher’s strong personality, ability to communicate directly with pupils and students and ability to look for more effective forms of education. But also on the other side the use of information and communication technologies, which have their indispensable place in the educational process, is crucially important; and therefore an informational base enabling students to apply acquire knowledge and skills in practice should be created. The teachers of mathematics can convey to their students a different perspective on how to solve some mathematical problems by using various mathematical programs. We can find various interesting programs that can be used in an educational process. Most of them are connected with geometry teaching. Geometric programs are used in teaching of plane and solid geometry as well as in the dynamic illustration of mathematical terms and relations. We can find...
various type of geometric software. As we already mentioned, GeoGebra as a freeware program is one of them. There exist also mathematical programs designed to facilitate mathematical applications in practice. Although their use is sometimes license tied they are sought after by teachers because they allow creation of other new programs. We can mention for example mathematical program MATLAB (see [18]). In spite of the fact that we know that MATLAB is used especially for performing numerical calculations we have MATLAB choosed, because our university has a Total Academic Headcount (TAH) license for MATLAB, Simulink, and add-on products. As we know MATLAB in its simplest form can be used as a matrix calculator. It advantage is that all common mathematical operations - such as multiplication, division, etc. are noted down on the paper. Thanks to this simple manipulation students with a low programming experience can obtain good results. It was reason why we decided to use these two mathematical programs – GeoGebra and MATLAB for solving tasks about functions \( f(x) = x^2 + 0.8|x-2| + 0.5 \), \( g(x) = x^4 - 0.02x^2 + 1 \) and \( h(x) = \frac{\sin x}{x} \) (see Figure 3, 4, 5, 6 and 8). The main aim was to find out whether the correct solution depend on the scale, it means, at the interval where is the function plotted. For the first time the function \( f \) was plotted in the same interval as in Figure 3, for \( x \in (-6, 6) \). In program MATLAB the interval was divided by the step 0.001. We achieved the same result as it was by using the program GeoGebra.

It was a reason why we repeated the task using the new step 0.0001. But even in this case, the correct result have not been achieved. Therefore the interval has also to be changed as it shown in the Figure 10.

When the problem was solved by using the functions \( g \) and \( h \) we obtained the same result, as it is seen in Figures 11, 12 and 13.

Application this mathematical software in the teaching of mathematics offers students and also teachers a new and creative way of thinking about the solving problems and helps them to develop
independent work and responsibility. Thanks to that, the algorithm of the problem solution which we want the student to learn is presented. It is the clarity and direct and active involvement of the student in the learning process that enables their to become its integral part and logically increases their interest in the subject. The correct use one of various mathematical software in the teaching/learning process improves the teaching of mathematics while at the same time it develops an active involvement of students in the subject matter, which at the same time supports the development of their logical and creative thinking. This is one of the reasons why it is necessary to incorporate the use some kinds of mathematical software in the educational process.

7 TASKS SUITABLE FOR APPLICATIONS

Application tasks is the most important place, when the confrontations between a man and mathematics are predominantly realised. They often play a submissive role in mathematics. Many application tasks are in fact „dressed“ tasks of pure mathematics. They mediate a certain mathematical unit or technique. It is often claimed that people who understand “pure mathematics“ have not any problems with its application. Typical tasks are so-called motion problems, which are presented with the help of sample exercises. They mediate solution techniques. But is this really the only purpose of motion problems? Let’s state a concrete example – traffic lights accidents whose frequency is dependent on the yellow light and subsequent red light time span (see [13]). Don’t we come across this situation in real life? From a mathematical viewpoint the following questions or working tasks for students arise:
- what the causes of accidents are,
- what counter-measures could be efficient,
- what calculations could be significant for a driver,
- what formulas can be used,
- what recommendations could be given for the problem solution?

Not only motion problems provide us with the possibility of practical mathematical application. Another part of life where mathematics has an indispensable place is music. The most readable influence of mathematics can be seen in musical score. We can find bars, whole and half notes in it. In musical notation one bar is formed by several notes. It means that in a stated rhythm the notes of various lengths have to fit into a concrete bar. This process resembles looking for the least common denominator in mathematics. Music is also connected with fractions, exponential curves and periodical functions. For example – if we have a string which produces the tone C, then 16/15 of this string’s length (tightened by the same power) produces the tone H. An analogous situation arises also in connection with other tones. We come across exponential curves in piano strings or organ pipes arrangement. Nowadays computers are used for music composition, human voice generating and musical instruments designing. However, these procedures would not be possible without periodical functions. Thanks to them we are able to obtain an authentic electronic musical production. Mathematics helps with the analysis of an ideal sound. History and presence show that not only composers and musicians but also mathematicians and researchers in computer science will be irreplaceable in the process of music composition and reproduction (see [14]).

Application tasks were dominated in the historical mathematics textbooks. Now we continue with two examples from textbook of Václav Posejpal: Aritmetika pro ústavy učiteľské (Arithmetics for Teachers´ Institutes, see [15]).

We start with the following quadratic equation with real parameter \( b \) from this textbook:

\[
3x^2 - (b - 9)x - 3b = 0 \quad (1)
\]

Discriminant of this equation is

\[
D = (b - 9)^2 + 36b = b^2 - 18b + 81 + 36b = b^2 + 18b + 81 = (b + 9)^2.
\]

Figure 14. Graph of the function \( f (x) = 3x^2 - (b - 9)x - 3b \) in the case \( b = -9 \).
If \( b \neq -9 \), then \( D > 0 \) and equation (1) has two solutions:
\[
x_{1,2} = \frac{(b - 9) \pm |b + 9|}{6}.
\]
Hence
\[
x_1 = \frac{b}{3}, x_2 = -3.
\]
If \( b = -9 \), then \( D = 0 \) and equation (1) has one solution: \( x = -3 \).
This equation has also geometrical interpretation. Every parabola \( y = 3x^2 - (b - 9)x - 3b \) must obtain the point \([-3,0]\) (see also Figure 9).

Second example is suitable for physics education. We have two pendulums, which simultaneously pass equidistant position at the same time. The period of motion of the first pendulum is \( T_1 = 3 \) seconds and the second pendulum movement period is \( T_2 = 4 \) seconds. What time will the two pendulums pass through a parallel equilibrium? How many oscillations for this time make each pendulum?

Figure 8 shows that the first moment, in which two pendulums pass through a parallel equilibrium, is in our case after 12 seconds. This example connect physics and mathematics education.

\[f(x) = 2 \sin \left( \frac{2 \pi}{3} x \right)\]
\[g(x) = 2 \sin \left( \frac{2 \pi}{4} x \right)\]

Figure 15. Motion of two pendulums with periods \( T_1 = 3 \) seconds and \( T_2 = 4 \) seconds.

Figure 14 shows that the first moment, in which two pendulums pass through a parallel equilibrium, is in our case after 12 seconds. This example connect physics and mathematics education. Generally, if periods \( T_1 \) and \( T_2 \) are natural numbers in seconds, two pendulums pass through a parallel equilibrium after the time, which is the least common multiple of the periods \( T_1 \) and \( T_2 \).

8 CONCLUSIONS
We present in our contribution the changes in Slovakian curricula in the field of mathematics education and we also show some consequences from this process to the pupils and students at every stage of schools. Similar trends is possible to see also in science education (see [16]).

Education passes through paradigms, which more or less respond to a broader context, the social and cultural atmosphere. It is therefore necessary to realize that education and training, like human society, are carried out in complex conditions. These conditions are constantly improving, resulting to their change. The above development is associated with both the past and the presence, but the future as well.

Against the background of increasing connection among human beings and the present globalization problems, we should not forget the connections of processes of education and training with the rest of the world around us. It is connected with a wide range of problems requiring not only a beneficial solution towards the perspective of the man and his humanity, but also advice of innovation in education and training. It serves us ICT in mathematics education (see [17]).

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REFERENCES


Virtual Keyboard Application for Students with Learning Disabilities in Thailand

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ABSTRACT

In Thailand, the number of students with learning disabilities is increasing whereas the use of assistive technology is limit. Assistive technology will help increasing ability or adjusting proficiency of students with learning disabilities to learn effectively. Most of the students with learning disabilities face problems with vocabularies spelling and writing. The issue thus prompted the authors to recognize the urgency in providing the support for these students and enable them to keep up with the colleagues. Accurate vocabularies writing and spelling are the essential skills required to be improved among these students. As a result, the authors have studied the writing patterns of these students and utilize the findings as a basis for the development of the instrument, which was the mobile application serving as the virtual keyboard (or Learning Disability Keyboard, LD Keyboard). The application as assistive technology aimed to solve the mistakes of vocabularies writing caused by the language literacy disorders. As the users type the vocabularies using this virtual keyboard, it will automatically correct the typing errors because of language literacy disorders with the accurate or similar words as well as displays the definitions with pronunciations. The results of the pilot testing revealed that after the implementation of this virtual keyboard application, the writing skill of the students in the experimental group was significantly improved at 0.05 statistical level and it was found that the satisfaction on the application was mostly at the highest level.

KEYWORDS


1 INTRODUCTION

Children with learning disabilities are the group which required specific needs and assistance as they have difficulties regarding the literacy and calculation [1]. The children with the reading disorder are characterized by trouble with reading, reading quickly, difficulties in spelling words, clumsy reading or understanding what one reads. The children with the deficiency in the ability to write are associated with impaired handwriting, misuse of written composition, spelling error, and poor legibility. The children with difficulties in the calculation are facing a deficit in the ability to understand numbers and their values as well as confusion over the similar numbers and not able to comprehend the conceptualization. Additionally, some of the children with learning disabilities are accompanied by difficulties in learning skills other than the linguistic ones. The study, however, revealed that most of the children with learning disabilities are those having difficulties in reading and writing, and followed by the calculation disability [2]. The intervention provided for these children is thus aimed at the literacy instruction as it is the vital skill. The children without literacy shall be struggling in learning. Self-learning is currently possible for anyone with the emergence of advanced and modern technology which allow people to access the required information via the personal computers, mobiles, and other devices [3]. The children with low literacy skill are thus lacking behind others regarding the access to such information, news, and fundamental knowledge.

2 OBJECTIVES

1. To examine the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the intervention with the virtual keyboard application;
2. To make a comparison of the abilities to write the Thai vocabularies writing skill among Grade 4-6 students with a deficiency
in the ability to write prior and after the intervention with the virtual keyboard application;  
3. To investigate the levels of satisfaction on the LD keyboard application among Grade 4-6 students with a deficiency in the ability to write.

3 The Significance of the Study

The findings of the study shall provide the useful information in developing the virtual keyboard application to be applied by the instructor in the lesson planning to improve the literacy skill and provide the definitions of vocabularies for the students with learning disability.

Scope of the study

Population and samples:  
The population of the study was comprised of Grade 4-6 students with a deficiency in the ability to write. The samples were seven Grade 4-6 students with a deficiency in the ability to write enrolled in the first semester of the academic year 2017 using the purposive sampling method [4].

Hypotheses

1. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is satisfactory after the intervention with the virtual keyboard application;  
2. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is improved after the intervention with the virtual keyboard application;  
3. The level of satisfaction on the virtual keyboard application is high among Grade 4-6 students with a deficiency in the ability to write.

4 Methodology

The procedure of the virtual keyboard application test to enhance the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write was discussed below. The samples of seven cases were drawn from the Grade 4-6 students in the affiliation of the Bangkok Metropolitan Department of Education with a deficiency in the ability to write who enrolled in the first semester of the academic year 2017 using the purposive sampling method. The details of sample selection are as follows:

1. Make a contact with the teacher in charge of the school’s special education department and request the collaboration in coordinating with the executives and asking permission to collect the data. The samples were selected from the students with learning disabilities through the screening performed by Rajanukul Institute and seven cases were drawn which consisted of the students with poor spelling ability.

2. Conduct the pre-class test using vocabularies writing test comprised of 20 items. The ten writing test items were required to be written on the paper the other ten were required to be written on the tablet device. The classes were then provided to the students with the implementation of the virtual keyboard application for 20 sessions. The 40-minute class was provided from Mondays to Fridays for the period of 20 days during 12.00-12.40 hrs. The post-class test was then conducted using vocabularies writing test comprised of 20 items. The ten writing test items were required to be written on the paper the other ten were required to be written on the tablet device.

3. Perform the assessment of satisfactory on the virtual keyboard application among Grade 4-6 students with a deficiency in the ability to write. The scales for levels of satisfaction were as follows;  
The instruments used were the virtual keyboard application [5] and Thai vocabularies writing test.

The data were analyzed using statistical tools including the median, interquartile range [6], and the Wilcoxon Matched - Pairs Signed - Rank Test [7].

5 The Virtual Keyboard Application

The user interface design.
After installing the application on smartphone or tablet, the users can easily be able to access to the application by touching the icon Learning Disability Keyboard (LD keyboard, virtual keyboard).

Figure 1. LD keyboard Icon.

The users can select their own background.

Figure 2. Background of LD keyboard application.

The users can also adjust the font size by using the scale bar.

Figure 3. The scale bar.

The usage.
The virtual keyboard application can apply to use with every applications within the smartphone or tablet such as text editors and search engines. The users type vocabulary as guessed then touch the “LD” button (located on the bottom of the left corner) in order to start the searching function. The list of possible words will appear on screen as a candidate view (2 lines, each line has 3 vocabularies).

Figure 4. Searching Button.

Figure 5. Previous Button and Next Button.

The virtual keyboard application offers Speaker button, Dictionary button and Select button. The users can touch speaker button to listening to the pronunciation. They can touch dictionary button in order to learn the meaning of each vocabulary. The users use select button when they want that vocabulary to appear on screen. Therefore, these buttons help the students with learning disabilities to select the right vocabulary.
6 FINDINGS

Following the trial of the virtual keyboard application for enhancing the writing skill among Grade 4-6 students with a deficiency in the ability to write, the findings of the test were as follows;

1. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application were equivalent to 0 scores, the median was 0, and the interquartile range was 0. The overall competency level was poor. After the virtual keyboard application intervention, the scores were between 1-3, the median was 2, and the interquartile range was 0. The overall competency level was poor, which is inconsistent with the Hypothesis 1 expecting the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is satisfactory after the intervention with the virtual keyboard application.

The results from Table 1 indicated that the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write before the implementation of the virtual keyboard application were equivalent to 0 scores, the median was 0, and the interquartile range was 0. The overall competency level was poor. After the virtual keyboard application intervention, the scores were between 1-3, the median was 2, and the interquartile range was 0. The overall competency level was poor, which is inconsistent with the Hypothesis 1 expecting the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is satisfactory after the intervention with the virtual keyboard application.

The results from Table 2 indicated that the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write before the implementation of the vocabulary retrieval system were equivalent to 0 scores, the median was 0, and the interquartile range was 0. The overall competency level was poor. After the virtual keyboard application intervention, the scores were between 1-5, the median was 0, and the interquartile range was 2. The overall competency level was poor, which is inconsistent with the Hypothesis 1 expecting the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is satisfactory after the intervention with the vocabulary retrieval system.

Table 1. The scores, median, and interquartile range for post-intervention (paper writing) writing skill among grade 4-6 students with a deficiency in the ability to write.

<table>
<thead>
<tr>
<th>Student number</th>
<th>Pretest score</th>
<th>Level of competency</th>
<th>Posttest score</th>
<th>Level of competency</th>
<th>Scores difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full marks = 10</td>
<td>Full marks = 10</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Mdn</td>
<td>0</td>
<td>Poor</td>
<td>2</td>
<td>0</td>
<td>Poor</td>
</tr>
<tr>
<td>IQR</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. The scores, median, and interquartile range for post-intervention (tablet writing) writing skill among grade 4-6 students with a deficiency in the ability to write.

<table>
<thead>
<tr>
<th>Student number</th>
<th>Pretest score</th>
<th>Level of competency</th>
<th>Posttest score</th>
<th>Level of competency</th>
<th>Scores difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full marks = 10</td>
<td>Full marks = 10</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Mdn</td>
<td>0</td>
<td>Poor</td>
<td>2</td>
<td>0</td>
<td>Poor</td>
</tr>
<tr>
<td>IQR</td>
<td>0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6. Speaker Button, Dictionary Button, Select Button.
2. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application.

Table 3. A comparison of the abilities to write the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write prior and after the intervention with the vocabulary retrieval system (paper writing).

<table>
<thead>
<tr>
<th>Student number</th>
<th>Scores Pre-class (X)</th>
<th>Scores Post-class (Y)</th>
<th>Scores difference (D = Y-X)</th>
<th>Order of difference</th>
<th>Order of operations</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>+1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>+3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>+3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>+6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>+6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>+3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>+6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T = 28</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant at .05 level

The findings in Table 3 showed that the overall abilities to write the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write prior and after the intervention with the virtual keyboard application were statistically significant higher at .05 level, corresponding with the Hypothesis 2 anticipating the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is improved after the intervention with the virtual keyboard application.

The results from Table 4 indicated that the overall abilities to write the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write prior and after the intervention with the virtual keyboard application were statistically significant higher at .05 level, corresponding with the Hypothesis 2 anticipating the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is improved after the intervention with the virtual keyboard application.

Table 4. A comparison of the abilities to write the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write prior and after the intervention with the vocabulary retrieval system (tablet writing).

<table>
<thead>
<tr>
<th>Student number</th>
<th>Scores Pre-class (X)</th>
<th>Scores Post-class (Y)</th>
<th>Scores difference (D = Y-X)</th>
<th>Order of difference</th>
<th>Order of operations</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>+4.5</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>+1.5</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
<td>+1.5</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>+4.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>+4.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>+7</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>2</td>
<td>2</td>
<td>4.5</td>
<td>+4.5</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>T = 28</td>
<td></td>
</tr>
</tbody>
</table>

*Statistically significant at .05 level

3. The levels of satisfaction on the virtual keyboard application among Grade 4-6 students with a deficiency in the ability to write.

Part 1: Personal information of the respondents:

Table 5. Personal information of the respondents.

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Description</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Genders</td>
<td>Males</td>
<td>71.43</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>28.57</td>
</tr>
<tr>
<td>2. Ages</td>
<td>10 years old</td>
<td>28.57</td>
</tr>
<tr>
<td></td>
<td>11 years old</td>
<td>42.86</td>
</tr>
<tr>
<td></td>
<td>12 years old</td>
<td>28.86</td>
</tr>
<tr>
<td>3. School grades</td>
<td>Grade 4</td>
<td>28.57</td>
</tr>
<tr>
<td></td>
<td>Grade 5</td>
<td>42.86</td>
</tr>
<tr>
<td></td>
<td>Grade 6</td>
<td>28.86</td>
</tr>
</tbody>
</table>

Part 2: Details of satisfaction on the virtual keyboard application:

(1) The evaluation of the interface of the virtual keyboard application.

According to the assessment for satisfaction on the virtual keyboard application [8,9], the respondents were consisting of 71.43% males and 28.57% females. The respondents with the age of 10 years old were accounting for 28.57%, 42.87% for 11 years old, and 28.86% for 12 years old respondents. 28.86% of the respondents are currently in Grade 4, 42.86% in Grade 5, and 28.86% in Grade 6. Regarding the satisfaction survey on the virtual keyboard application, the first aspect was relating to the interface of the application which acquired the average score of 4.56 and the highest level of satisfaction [10,11]. The items of optimal font type...
on the screen, optimal font color, optimal descriptive symbol or visual explaining the meaning, and the optimal manual (more understandable for users) obtained the average score of 5.00, equivalent to the highest level of satisfaction, followed by optimal descriptive message explaining the meaning and optimal explanation for setting ease of navigation with the average score of 4.86 and the highest level of satisfaction.

Table 6. The evaluation of the interface of the virtual keyboard application.

<table>
<thead>
<tr>
<th>No.</th>
<th>Items of the evaluation</th>
<th>Levels of satisfaction X</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>User-friendly interface</td>
<td>5.00</td>
<td>Highest</td>
</tr>
<tr>
<td>1.2</td>
<td>Optimal font type on the screen</td>
<td>4.43</td>
<td>Highest</td>
</tr>
<tr>
<td>1.3</td>
<td>Optimal font size on the screen</td>
<td>5.00</td>
<td>Highest</td>
</tr>
<tr>
<td>1.4</td>
<td>Optimal font color</td>
<td>5.00</td>
<td>Highest</td>
</tr>
<tr>
<td>1.5</td>
<td>The optimal descriptive message explaining the meaning</td>
<td>4.86</td>
<td>Highest</td>
</tr>
<tr>
<td>1.6</td>
<td>Optimal descriptive symbol or visual explaining the meaning</td>
<td>5.00</td>
<td>Highest</td>
</tr>
<tr>
<td>1.7</td>
<td>Optimal narrative voice explaining the meaning</td>
<td>3.14</td>
<td>High</td>
</tr>
<tr>
<td>1.8</td>
<td>User-friendly on-screen vocabularies and ease of navigation</td>
<td>3.14</td>
<td>High</td>
</tr>
<tr>
<td>1.9</td>
<td>The optimal explanation for setting ease of navigation</td>
<td>4.86</td>
<td>Highest</td>
</tr>
<tr>
<td>1.10</td>
<td>Optimal manual (more understandable for users)</td>
<td>5.00</td>
<td>Highest</td>
</tr>
<tr>
<td>On the average</td>
<td></td>
<td>4.56</td>
<td>Highest</td>
</tr>
</tbody>
</table>

(2) The evaluation of the accuracy and efficiency of the virtual keyboard application.

Table 7. The evaluation of the accuracy and efficiency of the virtual keyboard application.

<table>
<thead>
<tr>
<th>No.</th>
<th>Items of the evaluation</th>
<th>Levels of satisfaction X</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1</td>
<td>The accuracy of the data retrieval</td>
<td>4.14</td>
<td>Highest</td>
</tr>
<tr>
<td>2.2</td>
<td>Processing speed</td>
<td>4.00</td>
<td>High</td>
</tr>
<tr>
<td>2.3</td>
<td>Ease of usage</td>
<td>4.25</td>
<td>Highest</td>
</tr>
<tr>
<td>On the average</td>
<td></td>
<td>4.13</td>
<td>Highest</td>
</tr>
</tbody>
</table>

The second topic of the satisfaction on the virtual keyboard application was the evaluation for the accuracy and efficiency of the virtual keyboard application which acquired the average score of 4.13, equivalent to the highest level of satisfaction. The ease of usage obtained the average score of 4.25 and the highest level of satisfaction. The accuracy of the data retrieval had the average score of 4.14 with the highest level of satisfaction. The processing speed which acquired the average score of 4.00 equivalent to the highest level of satisfaction.

The result of the data analysis was consistent with the Hypothesis 3 predicting that the level of satisfaction on the virtual keyboard application is high among Grade 4-6 students with a deficiency in the ability to write.

Furthermore, the survey for issues relating to the function of the vocabularies retrieval revealed the frequent disappearance of the virtual keyboard which required users to regularly restart the device as well as the problem of slightly distorted pronunciation for certain words and some of the vocabularies showed no meaning. The users were impressed with the opportunity for the students to perform the self-learning and research while paying great attention to the virtual keyboard application and easily find the required information which resulted in the desirable degree of knowledge and vocabulary usage skill.

7 CONCLUDING REMARKS

1. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application was poor, which contradicted to the Hypothesis 1 expecting the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is satisfactory after the intervention with the vocabulary retrieval system. This might be occurred due to the various factors including the fact that the students have the critical learning disability as evidenced from the pretest in which all of the students acquired 0 score despite they are currently studying in Grade 3-4. Their competency level was lower than the actual educational stage. The vocabularies which most of the students were not able to write such as "สระ Lưu" - sāmamāt (able), "สระ ติ" - sādpaa (week), "สระ ติ" - sūcarīt (honest), "โทรศัพท์" - thoorasàp (telephone), "ประโยชน์" - prâyōott (benefit), "กตัญญู" - katanyuu (gratitude), "สันักขี" - sāamakkhiī (unity), and...
รัฐบาล (government), among others. The trial stage was also relatively short and disrupted by activities which require suspension of the special session and resulted in the discontinuity. Some of the students also absent from sessions of Fridays due to the domestic necessity. Furthermore, the session which provided on the final daily class in the dedicated classroom which requires the students to move there is the time-consuming process. With these reasons, the students were still inaccurately writing the Thai vocabularies which affected their competency even after the implementation of the vocabulary retrieval system to be in the "poor" level of ability.

2. The Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write is improved after the intervention with the virtual keyboard application consistent with the Hypothesis 2 because the virtual keyboard application is the virtual keyboard application running on the Android operating system which assisting the students in better reading and memorizing the vocabularies with consonants, vowels, and intonation marks. The system also integrated with narrative voice and the students are able to look up for the vocabularies by themselves based on the flashcards instructing the students to enter the words on the tablet device and the queried vocabularies will appear along with their definitions. Typing with the keyboard was the attractive activity for the students and they displayed the interest in learning vocabularies through looking, listening to the guide pronunciation and read along which enable the memorization and comprehension with the vocabularies consisting of the initial consonant, vowel, intonation mark and final consonant which deviated from the word-ending-protocols. The above-mentioned reasons are the motivation for the students toward the learning. Despite the fact that the students acquired higher scores after the implementation of vocabularies retrieval, the pre intervention and post intervention scores are not considerably different. The analysis for the styles of writing by the students is, however, suggested that they were not able or inaccurately writing the vocabularies before the intervention with the omission of the consonant, vowel, and intonation mark in the words they have been instructed to write. The word-by-word review revealed that the students were able to write the consonant, vowel, and intonation mark constituting the vocabularies in the certain degree. This suggested that the students were beginning to memorize the words they learned and result in the improved writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application.

3. The level of satisfaction on the virtual keyboard application is highest among Grade 4-6 students with a deficiency in the ability to write, consistent to the Hypothesis 3 predicting that the level of satisfaction on the virtual keyboard application is high among Grade 4-6 students with a deficiency in the ability to write. This is the result of an interface design based on the comic characters which relevant and attractive for the students of this age. The font size on the screen is also optimal for the student's vision and typing. The choice of the font color which distinct from the background made it noticeable to read. The descriptive symbols or visuals explaining the meaning are located in the eye-catching position and notable. The vocabularies retrieval also provides the vocabularies retrieval with accurate meaning results and easily accessible from the screen with ease of usage for the students.

To sum up, the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application was poor. However, the Thai vocabularies writing skill among Grade 4-6 students with a deficiency in the ability to write after the implementation of the virtual keyboard application was significantly improved at 0.05
statistical level and the level of satisfaction on the virtual keyboard application is high among Grade 4-
6 students with a deficiency in the ability to write was highest.

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REFERENCES


