English language learning in virtual 3D space by visualizing the library content of ancient texts

István Károly Boda
Debrecen Reformed Theological University
Department of Mathematics and Informatics
Debrecen, Hungary
boda.istvan@drhe.hu

Erzsébet Tóth
University of Debrecen, Faculty of Informatics
Department of Library Informatics
Debrecen, Hungary
toth.erzsebet@inf.unideb.hu

Abstract—**In our paper we present the cultural background, the organizational principles, and the current implementation of our three-dimensional virtual library model (3DVLM) based on the hierarchical scheme of the ancient Library of Alexandria elaborated by Callimachus, the prominent ancient Greek poet and scholar in the 3rd century BC. Our objective is, on the one hand, to organize the library content around selected classical texts. On the other hand, we intend to support text-based autonomous language learning by providing preprocessed English language texts (e.g. the translations of ancient texts, relevant Wikipedia entries about the ancient period etc.) with the necessary dictionary, encyclopedic and background knowledge that might be useful for a foreign language learner to read, understand and memorize the provided English language texts more easily. With respect to the implementation of the 3DVLM, we chose the flexible and cloud-based MaxWhere Seminar System. After giving a short overview about the cultural background and inheritance of the Alexandrian period, we present the main concepts and organization principles of the 3DVLM applied to support both classical education and effective language learning in the virtual 3D environment.**

Keywords— Callimachus; Pinakes; Library of Alexandria; three-dimensional virtual library model; knowledge base of literary content; MaxWhere Seminar System; text-based language learning

I. THE MUSEUM AND ITS GREAT LIBRARY

On Alexander the Great's death Ptolemy I Soter transported his mortal remains to Alexandria and had a mausoleum erected for his respect. As a wise man, a general and diplomat he wished to continue Alexander's intellectual heritage and decided to make his kingdom the cultural centre of the 'Greek empire' and establish the world library. The Library of Alexandria, the Museum, the branch library of the Serapeum and his policy to attract famous scholars to settle down in the Museum formed a tradition which was accepted by all the following monarchs of Egypt down to the last member of the Ptolemaic dynasty, Cleopatra in the first century B.C. The Museum and its organic component, the Great Library were founded by Ptolemy I Soter in 283 B.C.

Demetrius of Phalerum was one of Aristotle's pupils who sought asylum in Alexandria because he had to flee from the political turbulences which took place in Athens. He is considered to be the first man who devised the idea of founding the Museum as a scientific institution. His duty was to collect Greek works that provided the central part of the Library of Alexandria, although this assumption is not confirmed by any authoritative evidence. According to *Letter of Aristeas* Demetrius was allowed to lead the Library and he reported continuously Ptolemy II about the progress of acquiring new papyri into the library holdings. It is interesting to note that Aristeas was a Jew and praised the Hellenistic tradition of Jewish literature to improve the relations between the Jews and Greeks in Alexandria [1]. Other reliable source can be referred to in connection with Demetrius' role in the development of the library that is *Prolegomena to Aristophanes* [2] written by Ioannes Tzetzes. This historical source probably has some information in common with Letter of Aristeas. If this information is in fact taken from the Letter of Aristeas, it can be regarded as the earliest reference to a daughter library, depicted as being „outside the palace" and added to the temple of Serapis in the Rhachotis quarter of Alexandria. The third surviving document which left for us was an anonymous 15th century Latin translation of *Prolegomena to Aristophanes* by Ioannes Tzetzes. It also refers to the branch library of the Library of Alexandria [1].

II. DIRECTORS OF THE LIBRARY OF ALEXANDRIA AND CALLIMACHUS' CATALOGUE

One of the Oxyrhynchus papyri (No. 1241) enumerates the leaders of the library: the first one was Zenodotus, who was followed by Apollonius Rhodius, then Eratosthenes, Aristophanes of Byzantium, Apollonius Eidographus, Aristarchus and Cydas can be mentioned in this order. This papyrus proves to be contradictory with Aristeas' statements about Demetrius' role and task in the library. Let us summarize the curriculum vitae and the most important achievements of the directors of the Great Library.

Zenodotus was born at Ephesus, later he worked as a grammarian in the second half of the 3rd century B.C. He was employed as tutor to the royal family and followed his teacher, Philetas in this position. He was appointed as the director of the library with the following title: „Head of the libraries [sic] in Alexandria". Tzetzes applied the above mentioned title in this sense „custodian of the books" which meant „keeper of the government archives" in the Hellenistic period. In the Soudas we find the fact that he was an epic poet. He is known to be the first scholar in Alexandria who accomplished the critical

edition of Homer, Hesiod and Pindar. Before discussing the life of the following library director, Apollonius Rhodius, let us pay our attention to the immense bibliographical work performed by the erudite scholar and poet, Callimachus who organized the ancient Greek literary works into main categories and sub-categories according to their genres.

Callimachus' birthplace can be found in Cyrene, Lybia. He was born before 300 B.C. His family background is aristocratic one and he earned his income by providing lessons in Alexandria, while making studies at the same time. He worked as a royal librarian in the Great Library of Alexandria between 280 and 245 B.C. He made a great effort to catalogue the papyri which were available at this time in the library holdings. He has realized his original idea successfully in the Pinakes („Tables") [cf. 7–13]. In addition to his huge cataloguing project, he was admired as a scholar-poet due to his more than eight hundred works created by himself. Let us quote from the work of Tzetzes which proves that Callimachus built the library catalogue: „… and Callimachus later wrote up the tables of [the works]". His popular saying was „A great book is a great evil" which appears in the work entitled *To Praxiphanes*, where he attacks the Peripatetic philosopher of this name. Though this saying seems to be clear in its meaning, in fact the reasons for reluctance to big books were mostly practical ones closely related to a librarian's preoccupation with cataloguing and shelf pace, when one takes into account the length of some of his own writings [1].

Concerning the architectural design of the Museum building we can conclude that there were other rooms where papyrus rolls were categorized before they were transported to the appropriate places in the Library. It is very likely that some of the books were placed in cupboards. The newly-purchased papyri were transferred to the „admissions room" on arrival for recension and textual correction, or for translation and copying, or for cataloguing and classification. When all these working processes had been carried out, the librarian forwarded these papyri into the storerooms, having primarily recorded their titles on the parchment labels. The library could not be regarded as a single large room as the majority of scholars thought in the previous 19th century. According to Galen „book storerooms" and the *oikoi* (small buildings or rooms) formed the library. Probably separate storerooms or group of storerooms were used for the different literary genres determined by Callimachus to make the retrieval of the works more efficient and to leave these storerooms for future enlargement, as no one could tell how large each section of the library would be when all the Greek literary works in the world had really been brought together [1].

Apollonius Rhodius succeeded Zenodotus immediately as the director of the library, while Callimachus continued his cataloguing work as a librarian. Apollonius' birth date is estimated between 295 and 290 B.C. in Alexandria. He obtained Rhodius name because he spent the great part of his life on the island Rhodes. He was Callimachus' pupil and a prominent epic poet of his time. His most popular work was *Argonautica*, a post-Homeric epic poem. He held the position of the director of the Great Library between 270 and 260 B.C. and at the same time he worked as the tutor of Ptolemy III Euergetes (his reign started from 247 to 222 B.C.). After the

publication of the Argonautica his pupil-teacher relationship with Callimachus was broken because they began to compete with each other as rivals. As a consequence of this Apollonius decided to move from Alexandria to the island Rhodes.

Apollonius was followed by *Eratosthenes*, another pupil of Callimachus who was born in Cyrene in 276 or 273 B.C. He studied in Athens and probably attended Zeno's lectures. Ptolemy III invited him to lead the library in 246 B.C. and continuously held this post until the reign of Ptolemy V Epiphanes (204-180 B.C.). His other duty was to be the tutor to the royal family. He stated clearly that the field of study of the literary scholar is different from that of the grammarian. Besides his literary interests he dealt with natural sciences.

Aristophanes of Byzantium as a library director was tutor to the royal family and a pupil of Appolonius Rhodius, Callimachus and Zenodotus. His birth is supposed to happen between 258 and 255 B.C. He was appointed as library director between 196 and 193 B.C., when Ptolemy V Epiphanes was an Egyptian ruler. We do not know if he held the post until his death. He passed away circa 180 B.C. when Egypt started to sink into a social, political and economic crisis. By the end of his life he finished the whole textual recension of the works of lyric, epic poets and dramatists. He regarded Menander with respect, whom he considered to be second only to Homer. He usually posed the question if the comic poet Menander imitated life or life imitated Menander's literary work [1]. Please note that comedy was explained by the Peripatetics as "the imitation of life" [3]. There is one episode in Aristophanes' life which reflects well for us the atmosphere in the Museum at this period of time. After 197 B.C. he was commissioned by King Eumenes II to travel to Pergamum to manage his new library, but as soon as the news of his plans to leave the Museum became known he was arrested and imprisoned to stop his journey.

Apollonius Eidographus took over the post of the directorship of the library in 180 B.C. We know only a small information about him. He may perhaps have received the descriptive phrase Eidographus (which means "the Classifier") because he was responsible for classifying lyric poems according to the musical mode for which they were composed (Phrygian, Dorian or Lydian) [3].

Aristarchus of Samothrace was a scholar with literary education who was born in 216 B.C. He lived in the royal court of Ptolemy VI Philometor (180-145 B.C.) in Alexandria. We do not know the exact dates when he was the appointed director of the library. He followed the long-term tradition by being also the tutor to the royal family. His writings were popular among the educated inhabitants of Alexandria. He contributed to the literary studies by writing more than eight hundred *Commentaries* on the works he edited, unlike his contemporary editors who provided their textual notes orally in the lecture room. He is appreciated as an authoritative interpreter and critic of ancient poetry. In 144 B.C. Ptolemy VII was killed on the orders of his uncle who later became Ptolemy VIII. All the people whose patron was the late king had to flee from Alexandria to save their lives. So Aristarchus settled in Cyprus where he is believed to have died. He was succeeded by an army officer named Cydas as the director of

the library. This appointment suggests that there was a general decline in the standards of scholarship in Alexandria after his departure [1].

After Cydas the Oxyrhynchus papyrus (No. 1241) enumerates four grammarians as the director of the library who were as follows: Ammonius, Zenodotus, Diocles and Apollodorus [4]. All of them were active under the reign of Ptolemy IX (Soter II) from 120 to 80 B.C. However it cannot be established clearly from this papyrus whether they held any official post in the library. Onesander was considered as the last director of the library who was the son of Nausicrates. According to an inscription which emerged in Cyprus Onesander was supported by Ptolemy IX who went into exile to Cyprus. After his return to Alexandria in 88 B.C. he appointed Onesander to be the director of the library and his personal priest as well [1].

III. BASIC CONCEPTS AND ORGANIZATION OF THE 3D VIRTUAL LIBRARY MODEL

The 3D virtual library model (3DVLM) has been primarily designed to provide selected English translations of ancient Greek literary texts in order to support users who do not have widespread and sophisticated background knowledge on the field of erudite culture, and even lack the necessary linguistic competence to understand literary (and especially poetical) language. The 3DVLM and its various implementations have been being developed as part of the CogInfoCom research focusing on the efficient organization and visualization of the presented content [5–8]. The virtual library, intended to serve the preservation and transmission of classical cultural heritage and text-based autonomous language learning at the same time, should provide the necessary dictionary, encyclopedic, and background knowledge within a carefully designed cognitive framework called knowledge base [9–12]. Using modern ICT the library content is organized, visualized and presented in the flexible three-dimensional environment of the MaxWhere Seminar System [13,14]. The model is based on the main ideas of the classification system invented by Callimachus and developed further by other librarians (e.g. Apollonius Rhodius, Apollonius Eidographus etc.) in the Library of Alexandria.

In the 3D space of the MaxWhere Seminar System there are a number of carefully arranged *smartboards* which operate as multiple web browser windows; e.g. in the 3D Castle space designed by Ameda Cool Catz there are 30+1 smartboards arranged in five rows and six columns [14]. This unique and very flexible feature of the MaxWhere Seminar System embeds and presents web-based (i.e. HTML/CSS/JavaScript) content in the 3D space, with all the well-known advantages of hypertext and hypermedia (with unlimited verbal content, various colors, typography, links, images etc.). The current implementation of the model fully exploits the hypertextual organization of texts inside the smartboards of the MaxWhere Seminar System. As a result, the web-based focus and 3D organization of the virtual library content have become the utmost feature of the model [13].

As the basic units of the organization of the library content, the virtual library has virtual rooms, cabinets, labels, left and right corridors, and cabinet walls (which are metaphors in the 3D environment). Mapping the 3DVLM into the 3D space of the MaxWhere system is based on the following simple rules:

– a virtual room corresponds to a specific 3D space (e.g. a large room containing a number of smartboards);
– a cabinet with left and right corridors and cabinet walls corresponds to a group of adjoining smartboards created and arranged according to the architecture and design of the chosen 3D space;
– a label (in the form of a text or an image) contains a selected title of the content presented in a given cabinet.

The smallest units of the presented library content are located or 'exhibited' in designated smartboards representing the cabinets of the 3DVLM in the virtual room. The content of every cabinet consists of a carefully prepared English text, selected from the collection of the virtual library. The texts of the cabinets are presented as **slides** (e.g. with limited size, rich typography, various colors etc.) in order that the users of the library can easily read, understand and learn them, possibly 'at once'. Each cabinet contains a **label** which refers to the content of the cabinet. Using spectacular typography (striking contrast, colors etc.) the visitor of the 3D space might immediately catch sight of the labels which identify the referred content and show the place where it can be accessed.

The content represented in the left and right corridors and cabinet walls adds supplementary information for the cognitive processing of the English language texts presented in the cabinets. Metaphorically speaking, the *cabinets* are windows in the virtual 3D space to the *content* of the virtual library (i.e. a hyperspace of verbal units); and the intertwined *corridors and walls* lead the library users to a virtual maze or labyrinth built from selected dictionary entries, synonyms and related words, selected concordances or quotations, explanations of keywords in the form of short encyclopedic entries etc. In this metaphor, learning is building the mental representation of the labyrinth (including the texts to be memorized). The main pillars of the organization of knowledge in the 3DVLM are as follows:

• the **cabinets** contain the main library content to be read and memorized (e.g. slides about Callimachus, the ancient Library of Alexandria, the Pinakes etc. as well as epigrams written by Callimachus and other literary texts; a group of smartboards can be seen in Fig. 1 and 2; the symbols of the slides, e.g. S01, S03, S04, C30, C37 etc. can be seen in Fig. 3);
• the **right corridors** represent selected encyclopedic entries which might be required to understand the content of the cabinets (e.g. slides about Cyrene, the Ptolemaic dynasty etc., see e.g. X12, X21 etc. in Fig. 3);
• the **left corridors** represent selected vocabulary items (e.g. pronunciation and explanation of unknown words) necessary to understand the content of the cabinets. In several cases a link is available to the thesaurus entry of synonymous and related words. Metaphorically speaking, the dictionary entries of the left corridors form a *cloud of words* connecting the content of the cabinets, via selected keywords, to the corresponding thesaurus entries of the cabinet walls;
• the **cabinet walls** contain a collection of concordances of selected keywords from a group of semantically related words. The concordances are selected to fit a given collocation pattern (called *microcontext*) and often provided with the original

context and/or short explanations (which can be either a text represented in some of the cabinets or an encyclopedic entry represented in the right corridor). Generally speaking, the cabinet walls represent thesaurus entries enriched with selected concordances and their contexts (e.g. an entry about people with respect and productivity, or an entry about excellence or perfection etc., see e.g. T01 or T07 in Fig. 3).
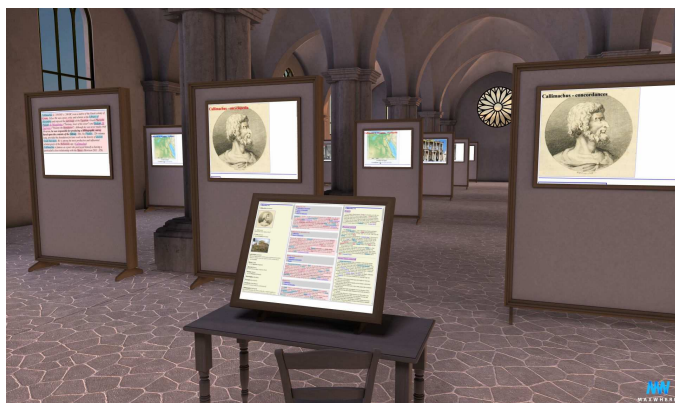

Fig. 1. The first row in the 3D Castle space in the MaxWhere Seminar System (the slide about Callimachus is the first smartboard from the left).

Fig. 2. The second row in the 3D Castle space in the MaxWhere Seminar System (the slide about Callimachus is the second smartboard from the left).

As we have seen, the main content of the 3DVLM is presented in cabinets, as well as corridors and cabinet walls, placed and neatly arranged in the virtual room (implemented in the 3D space). In the virtual library we offer several *navigation tools* to the library users which are referred to as **information desks**. Their main function is to support the efficient information retrieval of the library content. In the current implementation of the 3DVLM based on the MaxWhere system the information desks are represented by dedicated web pages displayed in selected smartboards. They are as follows:

– A *category page* contains a short description and the two-level hierarchical arrangement of the main categories applied in the virtual library. The categories described in the page include the main literary genres of ancient works (e.g. epic poets, lyric poets, elegiac poets etc.) and the name of prominent authors (with a reference to the title of their most important works). The categories are arranged according to the ancient

classification scheme invented by Callimachus in the Library of Alexandria (see CLA in Fig. 3).

– The *index page* contains the main keywords used in the content of the virtual room (e.g. proper nouns). In addition, selected concordances of the keywords are available with references to the full texts where the concordances can be found (see KWI in Fig. 3).

– The *reference page* contains all sources which have been referred to in the content of the virtual library. It currently contains more than 350 entries (see REF in Fig. 3).

– The *collocation patterns* page contains direct links to the thesaurus items available in the virtual library as well as some frequently used sentence patterns occurred in the concordances of the corresponding thesaurus pages (see CPT in Fig. 3).

– The *navigation page* represents a kind of "navigation map" for a specific virtual room, including a short description of the available content as well as links to the location where it can be found. In addition, relevant connections between the content units are also displayed in the map. (Fig. 3 is an example of a navigation map in the current implementation of the 3DVLM.)

In the further implementations of the 3DVLM we intend to provide additional navigation tools for the users to help them find their way in the three-dimensional space of the virtual library and explore its content. It is especially important for language learners who are the primary target group of the possible users of the virtual library.

IV. TOWARD SUCCESSFUL TEXT-BASED LANGUAGE LEARNING IN A VIRTUAL 3D ENVIRONMENT

In a comprehensive CALL environment, there are several factors that affect the success of language learning, including the learning environment, the learners (their competence, skills, motivation etc.) and the learning materials with well-prepared learning strategies. These factors can be especially important in virtual worlds (VW), where "cognition and learning processes must be understood within a paradigm that includes the individual, the environment and the ways in which participants use tools/artefacts in the environment to assimilate new knowledge" [15].

Firstly, it is essential to choose a flexible and interactional *learning environment* for the language learning process, where the main language learning skills (listening, speaking, reading, and writing) and the modern ICT (multimedia equipments, internet resources, mobile devices etc., with special focus on the 3D environment) are fully integrated into a pedagogical context [16–18]. In our case, the use of 3D spaces provided by modern ICT applications (including elaborated virtual worlds as well as virtual and augmented reality) is especially important because *language learning by exploring the virtual 3D space can significantly expand the cognitive capabilities of the learners* exploiting their visual memory to its full extent – which, considered as a special visualizing technique, can be very effective in foreign language learning [19]. In addition, the extensive use of ICT provides a sense of familiarity and security for the members of the new generation of CE who "are already growing up in a kind of »co-evolution« with ICT" [6]. Their cognitive–social–technological relationships with ICT
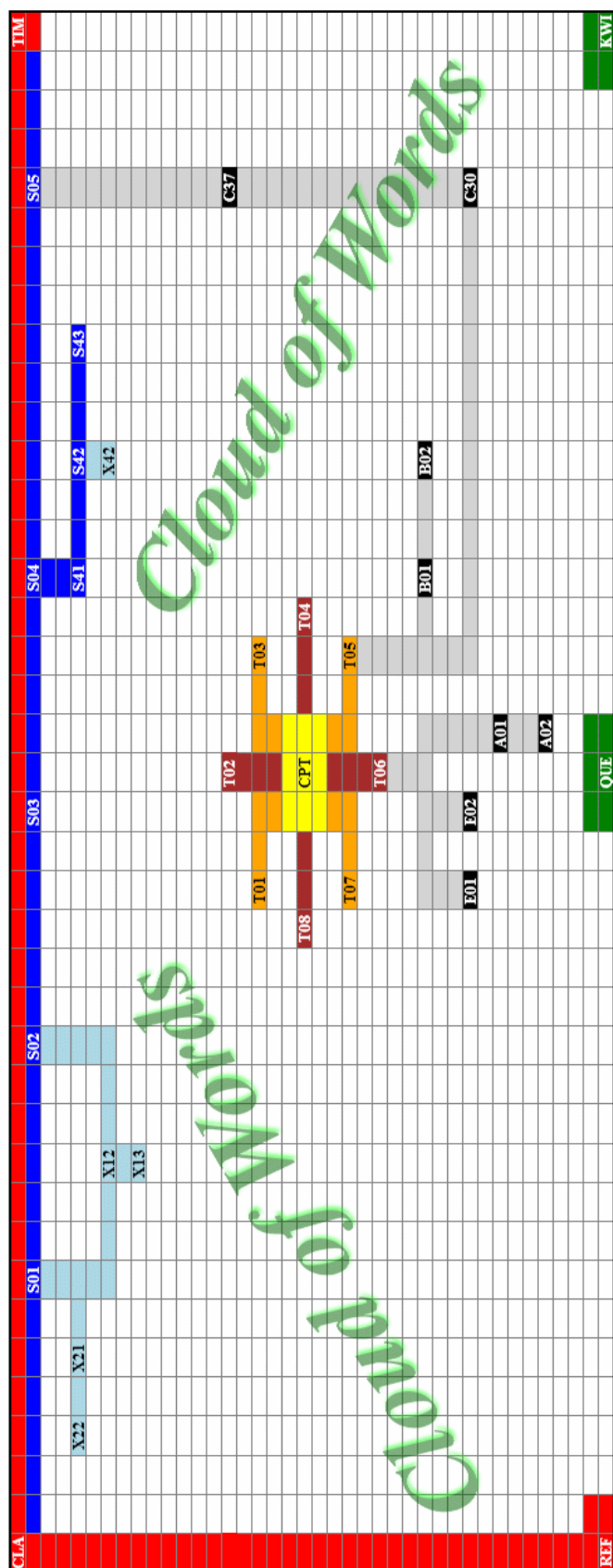
Fig. 3. The navigation map of a virtual room in 3DVLM.

might ensure personal and intimate involvement in the learning process. Which, among other things (e.g. providing authentic, interesting and engaging texts, challenging and interactive tasks etc.), can greatly contribute to the success of text-based language learning because "reading comprehension can be facilitated when students make personal connections to what they read" [20]. Providing authentic texts (e.g. classical literary texts) is also a key factor in autonomous language learning because they "tend to stimulate learners to further independent discovery and learning", which is even more so in a virtual 3D environment where fictional objects, places and even people can be created, and real buildings, churches, historical monuments etc. can be painstakingly reconstructed [21–22]. ICT plays a central role in this respect because "today's learners can reach out and touch 'real life' at the tap of the keyboard", ICT "has raised the profile of authenticity today" and "placing it squarely at the centre of contemporary pedagogy" [23].

The availability of various corpora in the internet, being either hand-assembled ('pedagogic') or computer generated, "increases the accessibility of an enormous amount of input in authentic contexts" [24]. Those corpora help to discover typical features of the language and to reveal common collocations and grammar "patterns in language which may not otherwise be visible" [25]. It raises the question to integrate corpora and concordances in the process of language learning [24–26].

With respect to our efforts to develop the 3DVLM in CALL context, the design and development of an efficient *learning material* is also of primary importance. There are several advantages in having the learning material built around a carefully designed and compiled knowledge base which provides all (or at least as much as possible) knowledge that should be processed and acquired during the learning process (e.g. vocabulary and encyclopedia entries, background materials, explanations, notes, illustrations, tables, diagrams, conceptual maps etc.). In our case, the knowledge base is organized in hypertextual form which provides an efficient and interactive means to have access to the relevant information, and allows us to establish as many inner relationships as possible between the content units (e.g. slides, vocabulary items, thesaurus pages, collections of quotations and concordances etc.) via hypertextual links. Moreover, it has a flexible and well-organized content which can be easily expanded with new materials. Metaphorically speaking, the knowledge base should be a vivid image or reflection of the human brain, i.e. the long term memory of the "ideal" language learner with its inherent data storage and cognitive capabilities. This metaphor is entirely consistent with the goal of the continuously developing field of cognitive infocommunications (CogInfoCom) which is declared as "to support the investigation of human-ICT entanglement related phenomena as well as how such phenomena lead to new cognitive entities and the appearance of the generation CE" [6]. Note that a great amount of language learners belong to the new social generations (called by either net generation, X, Y or Z generation or generation CE) who, because of their motivation, behavior and information processing habits, seem to be especially capable for VR-based education and training [27–28]. In our case, the attitudes of the potential users of the

virtual library are especially important, because for autonomous language learning (in the optimal case, learning by exploring in an interactive VR environment) strong interest and motivation is of primary importance. In this respect, the members of the generation CE can be considered as the primary target group of the potential users of the 3DVLM. For them, the 2D projection (that is, the html version) of the virtual library project is available in the internet.[1]

V. CONCLUSION

The term virtual reality is in a continuous change since its appearance in the 1960s. From the real breakthrough of the VR technology in 2016 the number of VR based applications has increased significantly in the consumer industry (e.g. gaming, entertainment etc.). One of the 2018 statistics[2] shows that while more than 70% of the users in Germany use VR for gaming, only 8% use VR for education and learning [28]. However, VR can provide efficient virtual workspace in various fields including education and learning as well as industrial environment (dual education and training, product design and simulation etc.). Therefore the emerging VR applications concerning these areas might have great potential, and they are to become a subject of rapid progress and development in the near future, including CogInfoCom aspects [28–30].

As an interactive VR application, the MaxWhere Seminar System can greatly facilitate and enhance the learning process. The virtual implementation of the classical Memory Palace Method (MPM) is an especially striking analogy [31] where the conceptual mapping of the content to be learned (read, understood, memorized etc.) can be based on various tools and organization principles. Some of these can be e.g.
– using different (and distinguishing) colors and shapes, various typography, images, interactive animations, videos etc. on the one hand, and
– content-based text segmentation,
– spatial arrangement of the content in a sophisticated and unique virtual environment functioning as a "memory palace" (e.g. a castle, a library, the auditorium of a theatre [32] etc.),
– hierarchical and/or sequential (scenario or "story-based") arrangement of the content units (e.g. proposing designated browsing paths or "breadcrumbs" and predefined navigation or preference points for novice users; providing spatial maps to locate and find assets to enhance navigational experience and create the sense of presence and immersion in the 3D space for experienced users), and
– the hypertextual organization of the whole material with browsing capabilities on simultaneously used smartboards in the virtual 3D space on the other hand [31, 33–36].

The general aim of the three dimensional virtual library project is to convey valuable parts of our classical cultural heritage using VR tools of modern ICT. The special, and more practical aspect of the project is to support autonomous, self-motivated language learning (e.g. "learning by exploring"). The virtual library contains well-prepared and authentic texts completed with the relevant dictionary, encyclopedic and

background knowledge in order that the average learner can "read and learn at once" the provided material. The content and organization of the knowledge base of the 3DVLM, and the 3D visualization of the library content in the virtual 3D space of the MaxWhere Seminar System are intended to arouse and maintain lively interest in the provided library content and, at the same time, to support effective language learning.

REFERENCES

[1] K. Staikos, "The hellenistic period: The Great Library of Alexandria," in K. Staikos, The great libraries: from antiquity to the renaissance (3000 B.C. to A.D. 1600). New Castle, Del.: Oak Knoll Press; London: The British Library, 2000, pp. 57–90.

[2] G. Kaibel, Die Prolegomena: Peri Kmidias. Norderstedt: Hansebooks, 2017.

[3] R. Pfeiffer, History of classical scholarship: from the beginnings to the end of the Hellenistic age. Oxford: Oxford University Press, 1968.

[4] P. M. Fraser, Ptolemaic Alexadria, vol. 2. New York: Oxford University Press, 1972.

[5] P. Baranyi and Á. Csapó, "Definition and synergies of Cognitive Infocommunications," Acta Polytechnica Hungarica, vol. 9, no. 1, pp. 67–83, 2012.

[6] P. Baranyi, A. Csapó, and Gy. Sallai, Cognitive Infocommunications (CogInfoCom). Springer International, 2015.

[7] I. Boda, M. Bényei, and E. Tóth, "New dimensions of an ancient Library: the Library of Alexandria," in CogInfoCom 2013. Proc. of the 4th IEEE International Conference on Cognitive Infocommunications, (Budapest, Hungary, December 2-5, 2013,) pp. 537–542.

[8] I. Boda, E. Tóth, M. Bényei, and I. Csont, "A three-dimensional virtual library model of the ancient Library of Alexandria," in ICAI 2014. Proc. of the 9th International Conference on Applied Informatics, (Eger, Hungary, January 29-February 1, 2014,) vol. 1, pp. 103–111.

[9] I. Boda, E. Tóth, I. Csont, and L. T. Nagy, "Toward a knowledge base of literary content focusing on the ancient Library of Alexandria in the three dimensional space," in CogInfoCom 2015. Proc. of the 6th IEEE International Conference on Cognitive Infocommunications, (Győr, Hungary, October 19-21, 2015,) pp. 251–258.

[10] I. Boda, E. Tóth, I. Csont, and L. T. Nagy, "Developing a knowledge base of ancient literary texts in virtual space," in P. Baranyi Ed. CogInfoCom 2016. Proc. of the 7th IEEE International Conference on Cognitive Infocommunications, (Wrocław, Poland, October 16-18, 2016,) pp. 263–270.

[11] I. Boda, E. Tóth, I. Csont, and L. T. Nagy, "The use of mythological content in virtual learning environment," in P. Baranyi Ed. CogInfoCom 2017. Proc. of the 8th IEEE International Conference on Cognitive Infocommunications, (Debrecen, Hungary, September 11-14, 2017,) pp. 307–314.

[12] I. Boda and E. Tóth, "From Callimachus to the Wikipedia: an ancient method for the representation of knowledge in the WWW era," in Gy. Sallai Ed. CogInfoCom 2018. Proc. of the 9th IEEE International Conference on Cognitive Infocommunications, (Budapest, Hungary, August 22-24, 2018,) pp. 205–210.

[13] I. Boda and E. Tóth, "Text-based approach to second language learning in the virtual space focusing on Callimachus' life and works," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 439–444.

[14] MaxWhere. http://www.maxwhere.com/ (2019-07-01); MaxWhere Store. http://store.maxwhere.com/ (2019-07-01)

---

[1] https://bodaistvan.hu/callimachus/map.html (2020-08-20)
[2] https://de.statista.com/infografik/14533/aktivitaeten-in-der-virtual-reality/ (2020-08-20)

[15] R. Sadler and M. Dooly, "Language learning in virtual worlds: Research and practice," in M. Thomas, H. Reinders, and M. Warschauer Eds. Contemporary Computer-Assisted Language Learning, Bloomsbury, 2013, pp. 159–182.

[16] M. Warschauer and D. Healey, "Computers and language learning: an overview," Language Teaching, vol. 31, no. 2. pp. 57–71, 1998.

[17] M. Thomas, H. Reinders, and M. Warschauer, "Contemporary computer-assisted language learning: The role of digital media and incremental change," in M. Thomas, H. Reinders, and M. Warschauer Eds. Contemporary Computer-Assisted Language Learning, Bloomsbury, 2013, pp. 1–12.

[18] D. Roy, "Understanding the value of website design and analysis in a comprehensive CALL environment: website analysis in a wider CALL environment," in B. Zou and M. Thomas Eds. Handbook of Research on Integrating Technology Into Contemporary Language Learning and Teaching, Hershey, PA: IGI Global, pp. 86–117, 2018.

[19] I. Drobot, "Foreign language learning: the use of images and the visual sense," International Journal of Management and Applied Science, vol. 1. no. 9, pp. 138–141, Oct. 2015.

[20] J. Jacobson, K. Johnson and D. Lapp, Effective Instruction for English Language Learners. Supporting Text-Based Comprehension and Communication Skills. New York – London: The Guilford Press, 2011.

[21] A. Gilányi, Gy. Bujdosó, and M. Bálint, "Virtual reconstruction of a medieval church," in P. Baranyi Ed. CogInfoCom 2017. Proc. of the 8th IEEE International Conference on Cognitive Infocommunications, (Debrecen, Hungary, September 11–14, 2017,) pp. 283–287.

[22] A. Gilányi, A. Rácz, M. Bálint, and K. Chmielewska, "Virtual reconstruction of historic monuments," in Gy. Sallai Ed. CogInfoCom 2018. Proc. of the 9th IEEE International Conference on Cognitive Infocommunications, (Budapest, Hungary, August 22-24, 2018,) pp. 341–346.

[23] F. Mishan, Designing Authenticity into Language Learning Materials. Bristol, UK – Portland, OR, USA: Intellect Books, 2005.

[24] Y. Wang, S. Lun and C. Suen, "EFL acquisition of english causative alternation with integrated concordances," in M. Levy et al. Eds. WorldCALL. International Perspectives on Computer-Assisted Language Learning. New York – London: Routledge, pp. 144–159. 2011.

[25] C. Tribble and G. Jones, Concordances in the Classroom. Harlow, Essex: Longman, 1990.

[26] J. Willis, "Concordances in the classroom without a computer: assembling and exploiting concordances of common words," in B. Tomlinson Ed. Materials Development in Language Teaching. Cambridge University Press, pp. 51–77. 2011.

[27] I. Horváth, "Behaviors and capabilities of generation CE students in 3D VR," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 491–494.

[28] F. Bellalouna, "Virtual-Reality-based Approach for Cognitive Design-Review and FMEA in the Industrial and Manufacturing Engineering," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 41–46.

[29] Z. Kvasznicza, J. Kovács, G. Maza, and B. Péli, "VR based Duale education at E.ON. The win-win-win situation for companies, graduates and universities," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 479–482.

[30] B. Borbála, "Desktop VR as a virtual workspace: a cognitive aspect," Acta Polytechnica Hungarica, vol. 16, no. 2, pp. 219–231. 2019.

[31] Á. B. Csapó, I. Horváth, P. Galambos, and P. Baranyi, "VR as a medium of communication: from memory palaces to comprehensive memory management," in Gy. Sallai Ed. CogInfoCom 2018. Proc. of the 9th IEEE International Conference on Cognitive Infocommunications, (Budapest, Hungary, August 22-24, 2018,) pp. 389–394.

[32] A. Gilányi, A. Rácz, A. M. Bólya, and K. Chmielewska, "Early history of Hungarian ballet in Virtual Reality," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 193–198.

[33] I. Horváth, "How to develop excellent educational content for 3D VR," in Péter Baranyi (ed.): CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 483–489.

[34] A. Sudár, and Á. B. Csapó, "Interaction Patterns of Spatial Navigation in VR Workspaces," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 611–614.

[35] B. Berki, "Sense of Presence in MaxWhere Virtual Reality," in P. Baranyi Ed. CogInfoCom 2019. Proc. of the 10th IEEE International Conference on Cognitive Infocommunications, (Naples, Italy, October 23-25, 2019,) pp. 91–94.

[36] B. Berki, "Does effective use of MaxWhere VR relate to the individual spatial memory and mental rotation skills?," Acta Polytechnica Hungarica, in print.

000312