Sequencing Wikipedia Pages: An On-the-fly Approach to Course Building

Fabio Gasparetti, Carla Limongelli, Alessandra Milita, Filippo Sciarrone and Andrea Tarantini
Department of Engineering, Roma Tre University, Via della Vasca Navale 79, Rome, Italy

Keywords: E-learning, Sequencing, Wikipedia.

Abstract: With its $5,006,202$ articles, 49 millions of registered people and on average 800 new articles per day, Wikipedia provides a knowledge base for teachers and instructional designers to build didactic materials. As a matter of fact, teachers often consult this encyclopaedia to arrange, integrate or enrich their courses. Moreover, with the exponential growth of the Internet, didactic materials are freely available and usable by teachers, instructional designers and students from Learning Objects Repositories such as *Mertlot* or *Ariadne* and others. On the other hand, designing and delivering a new course is a crucial task for teachers, who have to face two main problems: building or retrieving and sequencing learning materials. Retrieving or building learning materials requires a great effort and is time-consuming, while sequencing requires an accurate didactic project. In this paper we present a sequencing engine of learning materials, embedded in the *Wiki Course Builder* system, a system capable of retrieving and sequencing Wikipedia web pages, taking into account both the teacher model based on the Grasha teaching styles and on a social didactic approach. The main goal is to support teachers building on-the-fly courses, i.e., building courses quickly, with a few clicks of the mouse. An important feature of the system is represented by its ability to allow teachers to interact with the recommended learning path through a graph-based interface where they can directly modify the proposed learning path, adding or deleting Wikipedia pages. A first questionnaire has been submitted to a sample of teachers with encouraging results.

1 INTRODUCTION

Nowadays, the Internet can be considered a big repository of didactic materials, strengthening the lifelong learning era. *Wikipedia*[1] with its $5,006,202$ articles, 49 millions of registered people and on average 800 new articles per day has become one of the most visited didactic repositories, due to its simplicity of use and to its knowledge base, freely put on line by a huge and free community of experts such as teachers, instructional designers, scientists, and so on. Also, most people use Wikipedia as a readily available didactic material repository, quick and simple to consult (it does not require a registration process). On the other hand, if the use of Wikipedia in Education is still very controversial and Wikipedia contents are not always considered scientific contributions to be accepted in school, some learning experiences state that about 87%,[2] use the online Wikipedia Encyclopedia in their didactic activities. Furthermore, the reliability of Wikipedia, primarily of the English-language edition, has been also assessed: an early study in the journal Nature said that in 2005, Wikipedia's scientific articles came close to the level of accuracy of the *Encyclopedia Britannica*.

In this paper, we propose a system, called *Wiki Course Builder*, (WCB) that helps teachers to retrieve and sequence Wikipedia HTML pages taking into account both the model of the particular teacher that launched the query and the hypertext structure of the Wikipedia pages. The WCB system was first introduced in a previous work (Gasparetti et al., 2015c), mainly focussing on the retrieving capabilities of relevant Wikipedia pages, while here we address the sequencing engine module. This repository forms a huge semantic graph of relevant contents and we chose it as the system content source for its popularity among students, instructional designers and teachers. Moreover, people regularly use it as the starting point for knowledge building and for identifying general didactic goals, especially in a lifelong learning

[1] www.wikipedia.org
[2] www.pewinternet.org/2013/02/28/how-teachers-are-using-technology-at-home-and-in-their-classrooms/

Gasparetti, F., Limongelli, C., Milita, A., Sciarrone, F. and Tarantini, A.
Sequencing Wikipedia Pages: An On-the-fly Approach to Course Building.
In *Proceedings of the 8th International Conference on Computer Supported Education (CSEDU 2016) - Volume 1*, pages 397-404
ISBN: 978-989-758-179-3

context. In our system, through a suitable *GUI*, the user can input one or more keywords concerning the topic he/she is working on. Subsequently, the system analyzes the most relevant Wikipedia pages, returned by the embedded search engine, together with a proposal of a first sequencing of them. Both the retrieving and sequencing engines are based on the *Grasha Teaching Styles Model* (Grasha, 1996), a simple teaching model based on five dimensions of teaching. Each teacher registered into the WCB system is firstly required to take a simple standard questionnaire, the *Grasha-Riechmann Teaching Style Survey*, available at http://longleaf.net/teachingstyle.html and directly linked from the WCB system, receiving in output her teacher model. Besides, in the retrieving process, the relevance of a Wikipedia page is related to the set of the teaching styles tags associated to it: a Wikipedia page used by a teacher is tagged with her model (five dimensions). Subsequently, the sequencing is proposed by the system, basing on the links among the retrieved pages, on the Grasha teaching styles associated to each Wikipedia page already used by the community and on the model of the teacher that is building the course. In fact, each time a teacher inserts a retrieved document into her course, the document itself is tagged with her teaching styles, represented by an array of five real numbers, representing the Grasha model. As time goes by, this form of knowledge is acquired and exploited so that the repository content is automatically filtered. In fact, each Wikipedia page tagged by different users is weighed with the average of all the five dimensions of all the teachers that used it in a course. The well-known cold start problem of collaborative approaches is partially overcome by exploiting the first visits of the resources as soon as they become available. This is a straightforward and lightweight approach, well suited for a Community of Practice (CoP) (Wenger, 1998), where multiple users access and filter Wikipedia pages, with the common goal to quickly build a new course. The remainder of the article is structured as follows. Section 2 draws some important related work. Section 3 shows the teacher model the sequence engine is built on. Section 4 shows the system, i.e., the WBC system while Section 5 focuses on the sequencing engine. In Section 6 a first evaluation of the system is presented. Finally in Section 7 some conclusions are drawn.

2 RELATED WORK

Our proposal aims to sequence Wikipedia web pages basing on the teacher model, as defined by Grasha in (Grasha, 1996). So, Wikipedia, Grasha model and sequencing techniques represent the key concepts that set up our system.

To our knowledge, there is not much literature that considers the possibility to retrieve and sequence Wikipedia pages to build a new course, while there is some literature concerning the retrieval and sequencing of didactic material on the basis of the Grasha teacher model. The use of the Grasha model can be found in (Limongelli et al., 2015; Limongelli et al., 2016), where the teacher model is represented by a teaching experience and a dynamic semantic network composed by the retrieved and used learning materials by a community of teachers. In (Limongelli et al., 2013b) a clustering of teachers is proposed for a community of teachers.

One of the first works which have investigated Wikipedia as a learning support is (Forte and Bruckman, 2006). In particular, this work addresses the following research question: *Publishing on Wikipedia encourages students towards a collaborative and involving learning?*. Then, (Parker and Chao, 2007) highlights the didactic potential of wikis that actively involve learners in their own construction of knowledge, on the basis of a collaborative approach. Gasparetti *et al.* (Gasparetti et al., 2015b; Gasparetti et al., 2015a) propose an early attempt to exploit the Wikipedia content in order to determine prerequisite relationships among learning objects.

However, sequencing methods and techniques have been widely investigated. Generally, course Sequencing techniques can be classified in the following two main categories (Limongelli et al., 2009; Sciarrone, 2013):

- Sequencing that plans the entire learning path at the beginning of a course, modifying it if the study should not succeed as it should; e.g., *Dynamic Courseware Generation* (Brusilovsky and Vassileva, 2003), the work of Baldoni et al. (Baldoni et al., 2007)(Baldoni et al., 2004), and the IWT system (Sangineto et al., 2008; Limongelli et al., 2013a; Sterbini and Temperini, 2013);
- Sequencing obtained in an implicit way, step by step, through adaptive navigation support techniques, such as adaptive link annotation and direct guidance (Brusilowsky, 2001; De Bra et al., 2006; Limongelli et al., 2012a; Limongelli et al., 2012b).

All the aforesaid proposals take into account the student model required to build an adaptive sequencing engine. Our system does not take into account the student model but proposes the learning path on the basis of the teacher model only. Another important characteristic of our system is the use of Wikipedia as the source of didactic material. Wikipedia has been used as a didactic source in many attempts to extract useful information about the relevance of its contents. In particular, in (Milne and Witten, 2013) an interesting toolkit is presented to manage the Wikipedia contents by a semantic point of view. In (Strube and Ponzetto, 2006) a comparison between Wikipedia and WordNet is presented in the *WikiRelate!* system, to find semantic relationships among terms. In (Gabrilovich and Markovitch, 2009) a Wikipedia-based semantic interpretation for natural language processing is presented. A novel method, called Explicit Semantic Analysis, for fine-grained semantic interpretation of unrestricted natural language texts, is presented. This method represents meaning in a high-dimensional space of concepts derived from Wikipedia, representing the meaning of any text in terms of Wikipedia-based concepts. Another work worth of mention is that of Turchi et al. (Turchi et al., 2015) where the MediaWiki search engine, made available by Wikimedia Foundation to search contents among Wikipedia web pages, is used to test a ranking algorithm based on *Swarm Intelligence*.

In conclusion, the characteristics of our approach to the sequencing problem merges two research fields, the use of Wikipedia and the use of a teacher model. Both approaches have been used separately and in different contexts so far, while our proposal uses them synergistically.

3 THE TEACHER MODEL

The teacher model is a crucial element of our proposal because the sequencing engine is based on it and acts accordingly. The model building process starts with the Login module, by which the user can register and join the community of teachers. A database of users is built and managed by this module. When the user registers into the system, she is required to fill in a form with some personal data. It is in this step that the user is required to take the Grasha-Riechmann Teaching Style Survey[3]. It consists of a set of 40 5-points Likert-scale questions, such as: *Sharing my knowledge and expertise with students is very important to me* and *I give students negative feedback when their performance is unsatisfactory*. The questions aim at modeling the teacher by means of the following five dimensions:

- *Expert*: the teacher has the knowledge and the experience that students need;
- *Formal authority*: the teacher maintains her/his institutional role;
- *Personal model*: the teacher bases her/his teaching on personal examples and establishes a model for thinking and acting;
- *Facilitator*: the teacher emphasizes personal interactions between students and teacher;
- *Delegator*: the teacher develops the students ability so that they can act autonomously.

where each dimension is measured by a real number $d \in [1,5]$. In this way, when the user registers into the system, she is modelled by the set of the aforesaid five dimensions. Subsequently, this data will be used by the search engine. Fig. 1 shows an example of a teacher model as computed by the Grasha-Riechmann survey.

Figure 1: An example of teacher model: Expert=2.875, Formalauthorithy=3.625, Personalmodel=2.875, Facilitator=3.0, Delegator=1.625.

4 THE SYSTEM

In this Section, we show the general architecture of the system. The WBC system acts as a recommender system supporting teachers in building new courses, taking contents from Wikipedia, through a very simple and, above all, fast process. The teacher has the possibility to change, discard or review the recommended web pages, changing the proposed learning path as well.

4.1 The Architecture

The system is composed of some general functional modules (Gasparetti et al., 2015c), as shown in Fig. 2. Here we focus on the following subsets of modules[4]:

- The *Login Manager* Module. This module registers new users allowing them to enter into the system. Subsequently, it proposes the *Grasha-Reichmann Survey* by means the teachers can build their own teaching model, as shown in Section 3. Each teaching model is then stored in a local repository, ready to be used in the retrieval process;

[3]available at: http://longleaf.net/teachingstyle.html

[4]http://blacky.dia.uniroma3.it:9080/login.html

- The *Terms Manager* Module. This module manages the topic-terms and the context-terms inserted by the users during the query building process. These sets of terms are then passed to the search engine to retrieve relevant pages from the Wikipedia repository. Moreover, these terms are stored in the local repository, in order to display them in a Google-like way, when building a new query;
- The *Page Manager* Module. This module is composed of two sub-modules: the *My Courses* and the *Build Course* module. Through the first module the users can revise their courses, changing the learning paths, export the courses, and so on. The second module manages the sequencing engine, allowing to build new courses. Worth of mention is the capability of this module to display the graph of the connections among the retrieved Wikipidia pages. It helps teachers to have a simple and graphic interface to the recommended learning path in order to modify it, by adding or deleting learning nodes directly.

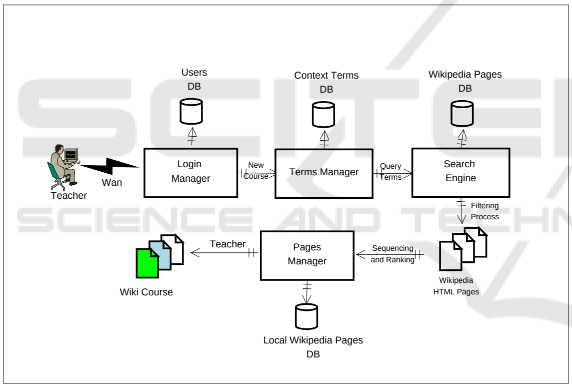

Figure 2: The general architecture of the Wiki Course Builder system.

5 THE SEQUENCING ENGINE

In this section we show the entire process of building a learning path to insert in a new or old course. The session starts with a teacher having the *My Courses* repository empty. Subsequently, the teacher can create a new course, as shown in Fig. 3 where a new course, concerning the *java programming language* topic, is to be created. Once inserted the topic-terms and the context-terms, the system returns those Wikipedia pages deemed relevant for the query. In fact, the user, through a Google-like interface, can specify the keywords in the first input text field (the topic-terms) together with other terms, to disambiguate the context (the context-terms), in the second text field. The system keeps track of all the topic-terms already inserted, with their related context-terms. Finally, clicking the *Submit* button, the system returns a group of Wikipedia pages, ranked on the basis of the distance between the teaching model of the teacher who launched the query and the teaching styles of each retrieved page, computed as an Euclidean distance metric D between the user teaching styles TS_k^u and the generic document TS_i^d:

$$D_{u,d} = \sqrt{\sum_{i=1}^{5}(TS_i^u - TS_i^d)^2} \quad (1)$$

The retrieved pages, displayed in a results-table, can be ranked also by means of the cosine similarity between the query and each Wikipedia retrieved page, by means of a TFxIDF terms-weighting technique (see for example (Baeza-Yates and Ribeiro-Neto, 1999)). The system uses the TFxIDF technique, which is not based on didactic features, only at the time t_0, that is when the retrieved pages are all *cold items*. Every time the teacher uses a retrieved page in a course, this page is tagged with her teaching styles. In this way, by the use of the system, each used Wikipedia page (i.e., a link to it) will be stored in a local database together with a set of the 5-tuples of the teachers who used it in their courses: if a teacher used a page n-times, this page will be tagged n-times with the user teaching styles. In this way, the system keeps track of the choices made by the members of the community, strengthening the social aspects of the page selection process. Obviously, in the Wikipedia repository, the topics do not have a uniform distribution in terms of number of related pages: it may be that for different topics there is a different number of related pages stored in the Wikipedia database. In the case of none of the Wikipedia pages should match the user query, other topic-terms are required. Moreover, the retrieval process could be more or less time consuming, depending on the granularity of the query. From the results table the user can perform the following actions:

1. Clicking the title of each page, after that the system proposes a new window showing the web page directly from Wikipedia. In this way the teacher can assess more accurately its content;
2. Changing the ranking algorithm: by Title, by Teaching Styles or by cosine similarity;
3. Clicking the *process* button to launch the sequencing engine. In this case, the system processes all the links belonging to that page and returns a sequence of three pages. Once the teacher has given

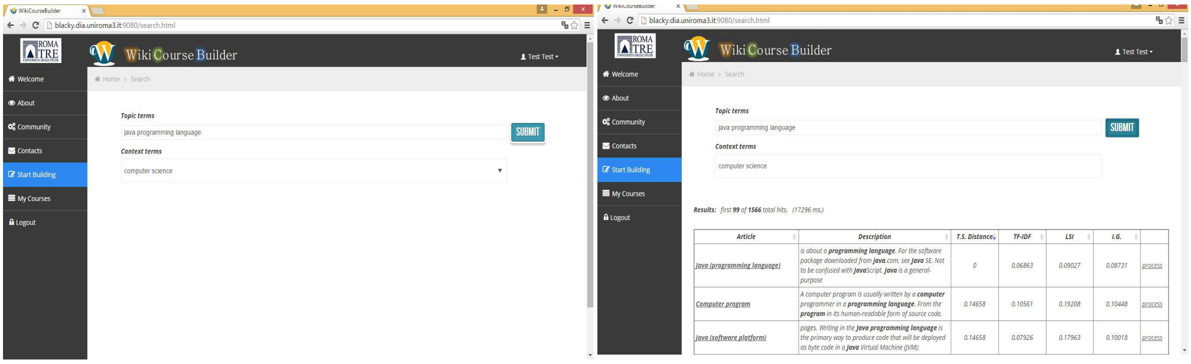

Figure 3: The Course Building Process. The left screen-shot shows the starting form where teachers can insert their topic-terms; the right screenshot shows the pages returned by the search engine for the *java programming language* query.

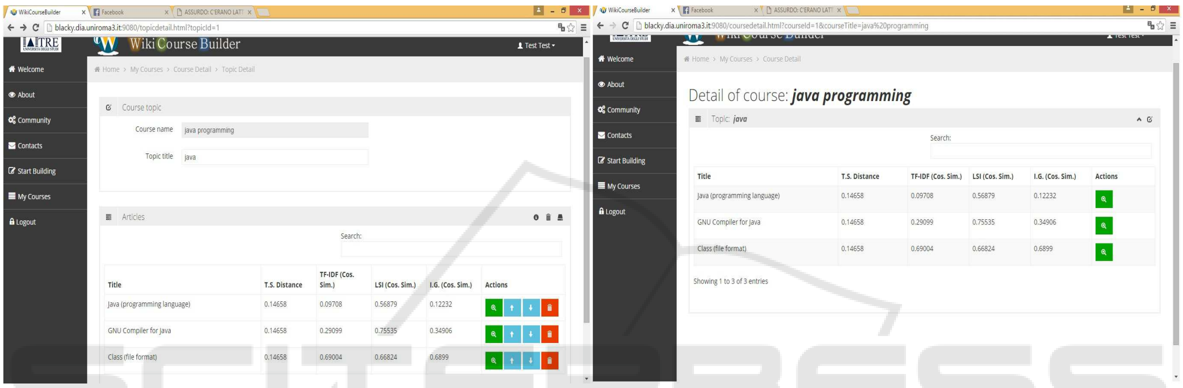

Figure 4: The sequencing process: the left screenshot shows the learning path returned by the system; the right screenshot shows the final learning path inserted into the new course (java programming language).

the new course a title and a description, by clicking on the *Apply* button, the new empty course is added to the *My Courses* list of the courses owned by her. In Fig. 4 the sequencing selection process is shown. For each course, users can view the details, change the title and/or description and delete the course. To store the new course and to make the changes effective it is then necessary to click the *save* button at the top right of the screen. Once created the course, the user can populate it with didactic contents.

In particular, the sequencing engine parses the Wikipedia page related to the *process* button, to identify its outbound links. For each linked Wikipedia page, the system selects the more promising page, including it in the recommended learning path. In the case of ties, the system uses the cosine similarity as it does in the previous phase of the search results ranking. These operations of parsing, calculating the Euclidean distance and selection of the most promising page are then repeated a finite and parameterized number of times. Currently the system is set up to compute three levels of depth, but the user can change this parameter. The returned learning path is shown in Fig. 4 where from the top of the list to the bottom a learning path consisting of three pages, is displayed. For each item of the results-set, the user can display it, move it up or down, changing the ranked list and delete it. After these operations, the learning path is inserted into the new course.

5.1 The Sequencing Graph Management

Another important feature of the system, is its capability to allow the user to visualize and to directly interact with the graph of the course by means of a graphical interface based on the *Gephi* graph manager, an open source software to manage graphs[5]. The system displays the graph formed by the learning path together with all the Wikipedia linked pages. Clicking on the *i* icon, the user launches the graph environment. In Fig. 5, highlighted in red, are shown the three nodes forming the recommended learning path. Clicking on a node, the system highlights all the links and all the nodes directly connected with it,

[5] www.gephi.org

both inbound and outbound, as shown in Fig. 6. On the left of the graph the system shows a frame containing some important characteristics of the selected node: the name of the page together with its link to Wikipedia, the distances computed both by teaching styles and cosine similarity for that node, the URLs of all the Wikipedia pages directly connected to it. By clicking one of these URLs, the system opens a new browser window displaying the selected page. In this way, the teacher can verify the quality of the learning path suggested by the sequencing engine checking for other topics to add to the recommended learning sequence, as shown in Fig. 6. To add a node to the learning path the user just selects it in the graph and then clicks the link on the left *Add this page to list*. The system opens a dialog box confirming the insertion. After having saved the course, each Wikipedia page included in this course is tagged with the 5-tuple of the teacher owner of the course. Moreover, when using the same Wikipedia page in different courses, this page is tagged with the Grasha 5-tuples of the

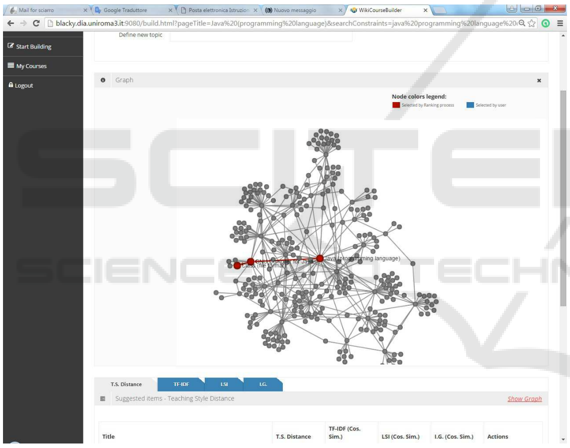

Figure 5: The graph with, in red color, the recommended learning path for the java programming language course.

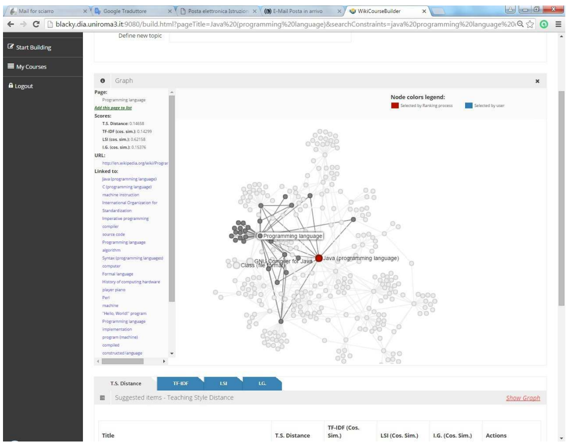

Figure 6: The user has clicked on the *java* node: the system proposes the *Programming Language* node.

course owner once more. For each Wikipedia page tagged by the system, the system stores its 5-tuples, indicating the teaching styles of the page and the number of contributions to its calculation. For example, if three users are using the same Wikipedia page, this page will be associated with the Grasha quintuple $[x_1, x_2, x_3, x_4, x_5]$, in which each element x_i is computed as the arithmetic mean of all the values of the three teaching styles of the users who have used it in their courses. Moreover, the system associates to each used page an incremental counter keeping track of how many users have used the page. The presence of the counter allows to obtain weighted values for the calculation of the new tags. If a user decides to delete a page from its course, the counter is consequently updated. Finally, at any time the user can return to the *My Courses* section to view the details of her course with the possibility to edit or delete it.

6 A FIRST EVALUATION OF THE SEQUENCING MODULE

In this Section we show a first evaluation of the sequencing engine. We submitted a happy sheet questionnaire, composed of 5 questions, to a sample formed by 10 teachers teaching in a technical high school with the aim to test the feeling of teachers with respect to the sequencing process. The sample was required to create a new course on a Computer Science topic. The following ten courses were built: motherboard, java language, array, microprocessor, switch, router, c language, Von Neumann, Turing and Unified Modeling Language. A question was about the usefulness of the recommended sequencing: *Did you find useful the sequencing proposed by the system?*. Another question was: *How do you feel the GUI of the sequencing module?*. The answers to the first question are shown in Fig. 7. 70% of the sample considered the system *useful* and *very useful*. In Fig. 8,

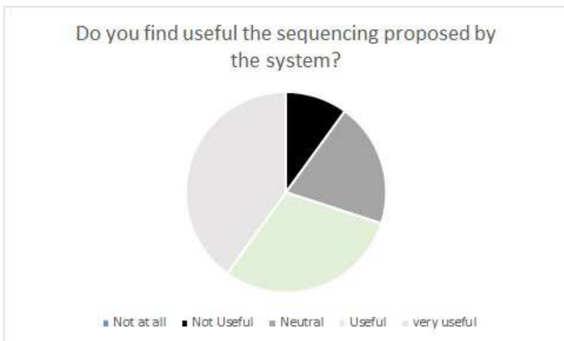

Figure 7: Do you find useful the sequencing proposed by the system?

are summarized the answers concerning the assessment of the system GUI. Finally, the 80% of the sample judged such interface as *simple* and *very simple* to use.

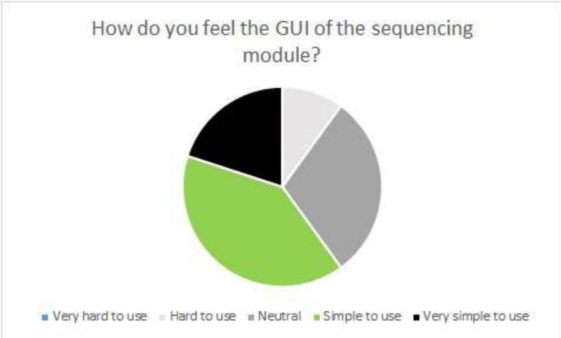

Figure 8: How do you feel the GUI of the sequencing module?

7 CONCLUSIONS AND FUTURE WORK

In this paper we presented the sequencing module of the WCB system, capable of helping teachers building and managing courses composed of *Wikipedia* pages. First, registered users are required to insert some topic-terms and secondly to insert some context-terms both to build the query and to help the search engine to disambiguate the Wikipedia pages. Subsequently, the system returns some Wikipedia pages sequenced by means of the user teaching styles, according to the Grasha teaching styles model. The teacher can accept the recommended learning path or change it both in terms of Wikipedia pages and in terms of a different learning path. Another important feature of the system is its ability to manage the graph embedding the recommended learning path proposed by the system: the user can click the nodes, adding them to the it. All the used pages are stored in a local database where they are tagged with the teaching styles of the teacher who used them. In this way, a CoP can grow and users can benefit of each others work. Currently the system is at its very early stage of development, running as a 3-tier web architecture, developed in java language and using the *wikipedia-miner* toolkit to interface itself to the Wikipedia database. Future work includes a full evaluation of all its modules with a large sample.

REFERENCES

Baeza-Yates, R. and Ribeiro-Neto, B. (1999). *Modern Infromation Retrieval*. Addison Wesley.

Baldoni, M., Baroglio, C., Brunkhorst, I., Marengo, E., and Patti, V. (2007). Reasoning-based curriculum sequencing and validation: Integration in a service-oriented architecture. In Duval, E., Klamma, R., and Wolpers, M., editors, *Creating New Learning Experiences on a Global Scale*, volume 4753 of *Lecture Notes in Computer Science*, pages 426–431. Springer Berlin Heidelberg.

Baldoni, M., Baroglio, C., Patti, V., and Torasso, L. (2004). Reasoning about learning object metadata for adapting scorm courseware. In *Int. Workshop on Engineering the Adaptive Web, EAW*, volume 4, pages 4–13.

Brusilovsky, P. and Vassileva, J. (2003). Course Sequencing Techniques for Large-Scale Webbased Education. *International Journal of Continuing Engineering Education and Lifelong Learning*, 13:75–94.

Brusilowsky, P. (2001). User modeling and user-adapted interaction. *Adaptive hypermedia*, 11:87–110.

De Bra, P., Smits, D., and Stash, N. (2006). Creating and delivering adaptive courses with aha! In *Proceedings of the First European Conference on Technology Enhanced Learning: Innovative Approaches for Learning and Knowledge Sharing*, EC-TEL'06, pages 21–33, Berlin, Heidelberg. Springer-Verlag.

Forte, A. and Bruckman, A. (2006). From wikipedia to the classroom: Exploring online publication and learning. In *Proceedings of the 7th International Conference on Learning Sciences*, ICLS '06, pages 182–188. International Society of the Learning Sciences.

Gabrilovich, E. and Markovitch, S. (2009). Wikipedia-based semantic interpretation for natural language processing. *J. Artif. Int. Res.*, 34(1):443–498.

Gasparetti, F., Limongelli, C., and Sciarrone, F. (2015a). A content-based approach for supporting teachers in discovering dependency relationships between instructional units in distance learning environments. In *Human-Computer Interaction. Theories, Methods, and Tools - 17th International Conference, HCI Los Angeles, CA, U.S.A., August 2-7, 2015*. To appear.

Gasparetti, F., Limongelli, C., and Sciarrone, F. (2015b). Exploiting wikipedia for discovering prerequisite relationships among learning objects. In *Information Technology Based Higher Education and Training (ITHET), 2015 International Conference on*. To appear.

Gasparetti, F., Limongelli, C., and Sciarrone, F. (2015c). Wiki course builder: a system for retrieving and sequencing didactic materials from wikipedia. In *Information Technology Based Higher Education and Training (ITHET), 2015 International Conference on*. To appear.

Grasha, A. (1996). Teaching with style: The integration of teaching and learning styles in the classroom. *Teaching Excellence*, 7:31–34.

Limongelli, C., Lombardi, M., Marani, A., and Sciarrone, F. (2013a). A teacher model to speed up the process of building courses. In *Human-Computer Interaction. Applications and Services - 15th International Conference, HCI International 2013, Las Vegas, NV, USA, July 21-26, 2013, Proceedings, Part II*, pages 434–443.

Limongelli, C., Lombardi, M., Marani, A., and Sciarrone, F. (2013b). A teaching-style based social network for didactic building and sharing. In *Artificial Intelligence in Education - 16th International Conference, AIED 2013, Memphis, TN, USA, July 9-13, 2013. Proceedings*, pages 774–777.

Limongelli, C., Lombardi, M., Marani, A., Sciarrone, F., and Temperini, M. (2016). A recommendation module to help teachers build courses through the moodle learning management system. *New Review of Hypermedia and Multimedia*, 22(1-2):58–82.

Limongelli, C., Miola, A., Sciarrone, F., and Temperini, M. (2012a). Supporting teachers to retrieve and select learning objects for personalized courses in the moodle ls environment. In *The IEEE 14th International Conference on Advanced Learning Technologies*, pages 518–520.

Limongelli, C., Mosiello, G., Panzieri, S., and Sciarrone, F. (2012b). Virtual industrial training: Joining innovative interfaces with plant modeling. In *The 11th International Conference on Information Technology Based Higher Education and Training - ITHET 2012*, pages 1–6. IEEE.

Limongelli, C., Sciarrone, F., and Temperini, M. (2015). A social network-based teacher model to support course construction. *Computers in Human Behavior*, 51:1077–1085.

Limongelli, C., Sciarrone, F., Temperini, M., and Vaste, G. (2009). Adaptive learning with the ls-plan system: A field evaluation. *IEEE Transactions on Learning Technologies*, 2(3):203–215.

Milne, D. and Witten, I. H. (2013). An open-source toolkit for mining wikipedia. *Artif. Intell.*, 194:222–239.

Parker, K. R. and Chao, J. T. (2007). Wiki as a teaching tool. *Interdisciplinary Journal of Knowledge and Learning Objects*, 3:57–72.

Sangineto, E., Capuano, N., Gaeta, M., and Micarelli, A. (2008). Adaptive course generation through learning styles representation. *Universal Access in the Information Society*, 7(1-2):1–23.

Sciarrone, F. (2013). An extension of the q diversity metric for information processing in multiple classifier systems: A field evaluation. *International Journal of Wavelets, Multiresolution and Information Processing*, 11(6).

Sterbini, A. and Temperini, M. (2013). Openanswer, a framework to support teacher's management of open answers through peer assessment. pages 164–170. IEEE.

Strube, M. and Ponzetto, S. P. (2006). Wikirelate! computing semantic relatedness using wikipedia. In *Proceedings of the 21st National Conference on Artificial Intelligence - Volume 2*, AAAI'06, pages 1419–1424. AAAI Press.

Turchi, T., Malizia, A., Castellucci, P., and Olsen, K. (2015). Collaborative information seeking with ant colony ranking in real-time. In *11th Italian Research Conference on Digital Libraries - IRCDL 2015 Bozen-Bolzano, Italy, 29-30 January, 2015*.

Wenger, E. (1998). Communities of practice: Learning as a social system. *Systems thinker*, 9(5):2–3.