Integrated Environment for Learning Programming

Martin Labaj, Marián Šimko, Jozef Tvarožek, Mária Bieliková

Slovak University of Technology in Bratislava,
Faculty of Informatics and Information Technologies,
Ilkovičova 2, 842 16 Bratislava, Slovakia

{name.surname}@stuba.sk

Abstract. In this demo paper we present adaptive educational system ALEF, which addresses several drawbacks of existing systems supporting learning programming such as limited support for specific adaptation, collaboration, and motivation resulting from complexity of learning programming, which must involve practicing and active experimentation. ALEF constitutes comprehensive annotation framework to support interaction and collaboration, motivation component for keeping learners engaged and extensible architecture allowing to include additional programming languages. ALEF has been used for 5 years at Slovak University of Technology and has served more than 1 200 students.

Keywords: learning programming, integrated learning environment, ALEF

1 Challenges in Support of Learning Programming

There are many domains where adaptive educational systems are successfully employed to support learning (many of them presented at conferences such as EC-TEL, ITS/AIED, UMAP). The advances in technology, web technology in particular, in the recent decade brought substantial advantages for interaction and collaboration [3]. It enabled interactive learning environments to emerge in order to support domains where learning from 'static' materials does not suffice. An example of such domain is learning programming. According to Kolb, a complete learning cycle includes active experimentation [6]. This particularly applies for learning programming, where theoretical mastering of (often abstract) programming concepts is not enough.

Many of educational systems created to support programming focus on automatic assessment of programming tasks, social support or adaptation during learning. Automatic assessment systems are widely used in university programming courses. Beyond managing submissions of programming assignments, returning feedback on correctness and assigning grades, these tools have evolved from command-line interfaces to comprehensive web-based tools that begin to integrate with learning management systems [5]. Recently, web-based programming support systems emerged to better support learning programming at various levels (writing code, debugging, analysing) by utilizing Web 2.0 features (e.g., [4]). Notable advances in adaptive support for learning programming can be found in works of Brusilovsky [2].

However, despite recent advances in technology enhanced learning programming, learners in majority of programming supporting educational systems may still encounter several drawbacks:

- *Limited support for adaptation.* Often no proper user model is built, user actions are stored on per-document (not per-concept or per-competence) basis.
- *Learning object type monotony.* Often only one learning object type is present on screen at a time. Explanations or exercises are presented separately.
- *Limited reusability.* Existing systems provide access to isolated materials in terms of reusability and shareability.
- *Lack of collaboration and active learning support.* No or just limited means to communicate, share ideas and collaborate on problem solving are often present. Learners are rarely involved in content creation and enrichment.
- *Poor motivation.* Despite the recent advancements, support for learner's motivation is not properly developed and/or integrated to the whole learning cycle.

In this demo paper we present educational system ALEF [8], which addresses aforementioned drawbacks. ALEF is a web-based adaptive learning environment with a strong emphasis on collaboration and learner's active participation in learning process. It encourages learners to be not only passive consumers of information, but also to communicate with peers, collaborate on problem solving and contribute to learning content and/or metadata [1]. Even though it was created as a general framework for support of adaptive learning, most courses provided during 5 years of its operation are within the domain of learning programming, which requires specific support.

2 ALEF: Integrated Adaptive Learning Environment

The content in ALEF is presented in three basic types of learning objects (LOs): (i) explanations (explaining topics, such LO is similar to a book section), (ii) questions (ranging from single-choice to plaintext input), and (iii) interactive exercises (a particularly important from the learning programming perspective). The user model (learner's knowledge model, based on lightweight domain model [9]) is inferred from the interaction with exercises, questions, reading explanations, using collaborative functions and other aspects of the system. It serves as a basis for *adaptation engine* employing different adaptation strategies [1].

Annotation Framework. The heart of ALEF's social side is its annotation framework consisting of in-text interaction and presentation, sidebar annotation presenter and annotation browsers ("widgets") [1]. Widgets are displayed around and within the content as a small windows suited for different purposes, e.g., allowing the learners to chat in groups, annotate the content via pop-up widget displayed after selecting a text, tagging the content, or navigating through it using the menu widget, adding links to external sources, or adding specific annotations such as own definitions of key concepts. Interactive content is also presented in widgets and as such, it can be included into other content, e.g., interactive exercises can be shown in appropriate places in explanations.

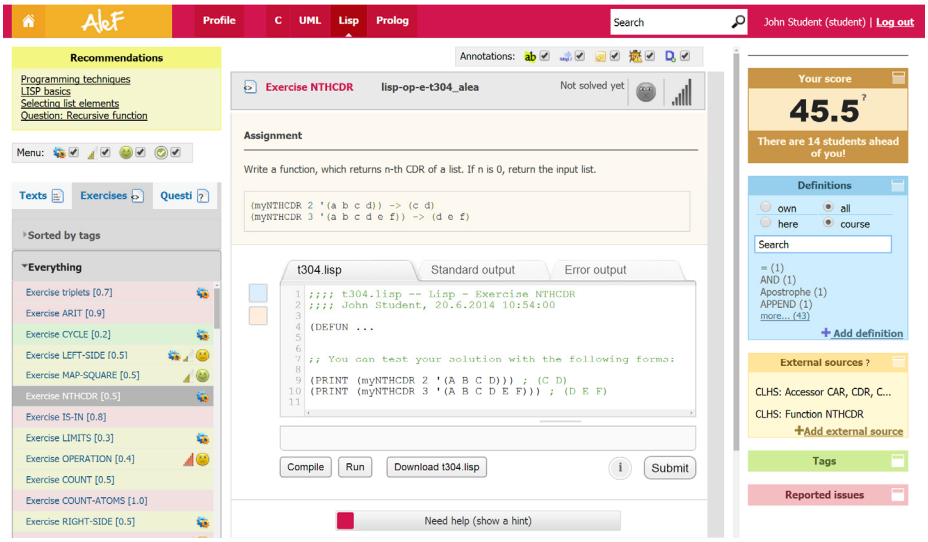

Figure 1. Screenshot of ALEF user interface. It is divided to three vertical parts (left to right): (i) navigational part with learning objects recommendations and menu; (ii) selected learning object with submission evaluator and (iii) learning and collaboration supporting widgets: score, term definitions, and external resources, other widgets (tags, issues in content) are shown collapsed.

Extensible architecture. ALEF's architecture was designed to allow interconnection with external systems and services in order to further improve learning experience. Connecting the learning programming environment with other environments requires multiple levels of cooperation. First, the user interface is shown in ALEF through the use of widgets (see Fig. 1). A *proxy integration widget* simply points the learner to another learning environment, e.g., collaborative UML tool, while showing notifications about news, task assignments, peer users, etc. from the other system. A *navigation integration widget* interfaces with the menu widget and allows selecting the content (e.g., another type of LO) presented within ALEF layout, but provided by different learning system. A *content integration widget* interfaces directly with the ALEF content, augmenting it with new features, e.g., adding a code editing and submission tool to ALEF exercises. External systems communicate relevant implicit and explicit user feedback to the ALEF for motivation rewards (user score, badges) and in order to augment the central user model, which is in turn provided to interconnected systems as a service.

We can observe an exemplary utilisation of ALEF's extensible architecture in incorporation of external services. ALEF has been integrated with external services at the university that provide interactive source code editing and submission evaluation [7]. It allows learners to write a program directly in the exercise widget and then compile it, test it using sample test inputs pre-defined in the exercise or using own test cases, and submit it for evaluation. In the case of incorrect submission, the learner is not only informed about any compile or run-time errors in the standard way, but also specific messages are configured for various passing/failing tests (e.g., cases gradually covering sample inputs from the exercise, then boundary cases, then large inputs) hinting the user what may be wrong with their code without revealing the test data.

Motivation component. A successful execution of learning tasks in ALEF is rewarded with badges and adds points to the user score motivating the learner to progress through the course. Learner motivation is maintained also through dynamic score, which reflects activity of the whole class.

ALEF in practice. ALEF supports education at our university since 2009 by providing adaptive interactive learning materials for 4 courses (Tab. 1). Students use ALEF both for homework and for practice during labs. They use annotation features for tagging and sharing text highlights or notes. We have an evidence of students' improvements both informally by monitoring their involvement and formally based on evaluation of tests results. We continually improve ALEF capabilities, mainly its collaborative and interactive features. E.g., we provided recently a component allowing learning from existing questions and answers provided by students and involving students into the answer correctness evaluation applying crowdsourcing principles.

Table 1. ALEF usage statistics (since 2009).

Course - programming	Learning objects	Students participating	Learning object visited	Exercises solved	Questions answered	Annotations created
Functional	308	146	29 121	2 106	3 878	3 843
Logic	235	127	12 004	988	370	2 061
Procedural	795	2 081	200 436	4 744	21 267	10 103
UML	694	1 184	434 163	2 290	12 366	40 377

Acknowledgement. This work was partially supported by the grants No. KEGA 009STU-4/2014, VG1/0675/11, VG1/0971/11 and APVV-0208-10.

References

1. Bieliková, M. et al.: ALEF: from Application to Platform for Adaptive Collaborative Learning. In: Recomm. Systems for TEL. Springer Sci+Business Media, New York (2014)
2. Brusilovsky, P.: Adaptive Hypermedia for Education and Training. In Adaptive Tech. for Training and Education.Cambridge University Press, 46-68 (2012)
3. Downes, S.: E-learning 2.0. eLearn magazine. 10, 1 (2005)
4. Hwang, W.-Y., et al.: A web-based programming learning environment to support cognitive development. Interacting with Computers. 20.6, 524-534 (2008)
5. Ihantola, P. et al.: Review of recent systems for automatic assessment of programming assignments. In: Proc. of the 10th Int. Conf. on Comp. Educ. Res., pp. 86-93. ACM (2010)
6. Kolb, D. A. et al.: Experiential learning theory: Previous research and new directions. Perspectives on thinking, learning, and cog. styles, 1, 227-247 (2001)
7. Návrat, P., Tvarožek, J.: Online Programming Exercises for Summative Assessment in University Courses. In: *CompSysTech'14*, Ruse, Bulgaria. Springer. (2014) (Accepted)
8. Šimko, M. et al.: ALEF: A framework for adaptive web-based learning 2.0. In: Key Competencies in the Knowledge Society, pp. 367-378. Springer (2010)
9. Šimko, M.: Automated Acquisition of Domain Model for Adaptive Collaborative Web-Based Learning. *Inf. Sciences and Tech. Bulletin of the ACM Slovakia.* 4(2), 1-9 (2012)