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The Prospect of Using Automatic Programming Assistant for Providing Direct Feedback in an Online Learning Environment

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Abstract

Formal education systems worldwide were faced with the challenge of shifting from classroom to online e-learning platforms due to the COVID-19 lockdown. The shift forced teachers to spend additional time on digital content management, as well as on individual communication to gain insight into student's cognition and provide feedback. In programming classes, especially at the university level, communication is often asynchronous. Since university students learn at their own pace, they run into issues that a teacher might have anticipated, but at different times and at different rates. Because communication is asynchronous, the need for teacher's feedback disrupts student's learning pace. In this paper, the application of a knowledge-driven feedback-providing automatic-programming Artificially Intelligent Teaching Assistant (AITA) is proposed as a solution to that problem. By using cognitive maps, a teacher could manage knowledge, more precisely, the concepts, the competencies, and tasks that are a part of the programming curricula. Similarly, AITA could manage metaknowledge about student's knowledge of concepts and competencies and would provide specific, direct feedback to students as the result in form of automatically generated programming code. Feedback would range from styling suggestions to fixes. This way, teachers would benefit from time savings, while students would benefit from adaptive learning mechanisms provided by AITA. This paper describes AITA's system architecture and presents the results of pilot testing as an answer to the challenge of shifting from classroom to online e-learning platforms due to the COVID-19 lockdown. This contribution is suitable for an international audience and the abstract content is consistent with the NPSE 2021 Conference guidelines.

Keywords: *programming, COVID-19, STEM education, knowledge management, adaptive learning, automatic programming*

1. Introduction

During March and the first days of April 2020, countries worldwide implemented the lockdown measures due to COVID-19 pandemic which caused schools and universities to close their classrooms and shift to online e-learning environments as alternatives to traditional classroom environment. As the result, teachers were faced with a time-consuming task of content creation and management because of the shortage of e-resources closely related to the curriculum and/or produced in the official language used in formal education. Even for programming courses, which benefit from the availability of great number of e-resources, teachers at Faculty of Science (FoS), University of Split, Croatia, had to spend significant amounts of time on content management alone. The idea of developing an automatic code generation system was born, driven by the need to generate programming code based on programming knowledge. By using such a system to generate content and serve it in a way that facilitates adaptive learning, teachers would gain time to focus on knowledge and learning management. While system's time-saving properties could potentially benefit teachers, it is its adaptive nature that is the most important feature because it would allow for automatic real-time content generation that would serve as a feedback provider and responder to learner's individual needs. Thus, content would be generated on-demand and as needed, individualizing learner's learning path in the process, while allowing teachers to manage, reuse and share their knowledge.

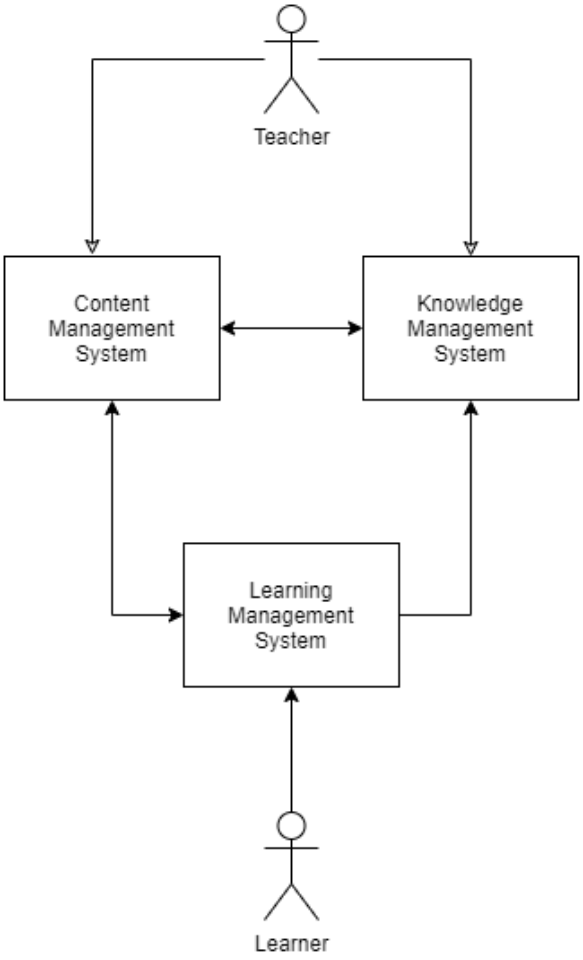

Fig.1. System architecture of the LORE (Learner Oriented Roleplaying Environment).

LORE is the idea of a system that would be adaptive in nature (Learner Oriented), considering different roles learners take during the learning process (Roleplaying) based on their personality types and other individual parameters that affect their learning habits.
LORE system would consist of three interoperable parts:

- Content Management System – a system accessed by a teacher for managing the curricular content
- Knowledge Management System – a system accessed by a teacher for managing the programming knowledge presented in a form of a concept map
- Learning Management System – a system with ability to manage learner's learning path based on programming knowledge, available content and learner's profile

Even prior to the COVID-19 lockdown, there was a need to include the characteristics of learner into learning scheme generation process, which mostly remained a manual process resulting in static and inflexible e-learning systems [1]. As a response, efforts have been made to generate individualized learning paths based on individual characteristics of the learner [1], such as personality type or learning styles, but also based on misconceptions assumed a learner to be forming [2].
The base activity of any adaptive e-learning system is the learning path generation. According to (Bhaskar, Manju, et al., 2010), a learning path is defined as following:
Learning path defines the sequence of learning activities that is carried out by the learner going through learning units in e-learning system. Learning unit is an abstract representation of a course, a lesson, a workshop, or any other formal or in-formal learning or teaching event.

Using the system for automatic code generation with adaptive learning mechanism, we set out to find the answer to the following two questions:

- Is feedback on average more frequently requested by certain Myer-Briggs personality types?
- Are certain programming misconceptions on average made mode frequently by certain Myer-Briggs personality types?

In the proposed system, the content would be partially automatically generated in the form of programming code, while the rest of the content would be prepared by a teacher but served to learners based on their individual needs. This part of the system is an automatic code generator that acts as an Artificially Intelligent Teaching Assistant (AITA).

As part of the knowledge management, a teacher would have to manage concepts and competencies covered by the curricular content by connecting them to form a knowledge map, while mapping them to each atomic piece of curricular content. This way, adaptive learning mechanism could map the learner's achievements to the knowledge map and serve appropriate content based on its metaknowledge of student. In that way, the system would help manage the learning, yielding helpful analytical data in the process which a teacher could use to start the conversation with individuals about misconceptions they formed.

2. Problematization

During the COVID-19 lockdown, three major issues related to content, teacher and learner have been experienced, and they are the following:

- Content production and management is time-consuming
- Misconceptions are harder to perceive in an online e-learning environment
- The lack of face-to-face interaction with the instructor, longer response time due to different times and rates at which learner's access the content, absence of traditional classroom socialization [3]

Based on the observations made during the past two semesters at FoS that were affected by the pandemic, we assume that learner's personality type affects the way they interact with teacher and the content. While extroverts are more open to requesting feedback, which would be granted to everyone in a classroom environment, that feedback was requested and granted on the individual level in the online environment instead, affecting the amount of knowledge introverted students would usually gain without any interaction. Besides that, intuitive learners and feelers were more inclined to forming misconceptions. Both assumptions should be tested and verified in a controlled environment.

Based on intuition, we formed an assumption that, even though learner's personality type might play a significant role in the forming of misconceptions, their lack of precognition might be more influential than their personality type is.

Future studies should include learner's personality types [1, 4], along with cognitive load theory and constructivist theory [5], in order to form a framework for generating individualized learning paths, before a learner accesses the learning unit, but also after their work was assessed. We will set out to find the effects of misconceptions on programming learning path for different types of learners.

The motivation for this type of research lies in the fact that FoS is involved in the programming education of many different groups of students, including Chemistry Engineering, Chemistry, Physics, Mathematics, Computer Science and Polytechnics students, each with a different precognition level, motivations, personality types and learning styles.

3. Conclusion

COVID-19 pandemic significantly impacted formal education systems worldwide, forcing the members of those systems to undergo a lockdown, thus learning and teaching in isolation. This resulted in time consuming efforts to manage e-content, indirect communication, additional efforts to manage learning otherwise done effortlessly within a classroom, making online e-learning environment a fertile ground for misconceptions to be formed. Further studies are necessary to find out how cognitive load of an individual is being impacted in an online learning environment, based on learner's personality type, precognitions, motivation and various other personal factors that might prove to be significant. For this purpose, a system architecture of the system named LORE is proposed. With it, we plan on introducing adaptive learning mechanisms for individualized content serving, with goals of decreasing both teacher's and student's load.

Reducing the load is of major importance since it demotivates both teachers and students from using e-learning systems frequently. Since the pandemic began, the time spent on content and learning management outside the classroom has increased for us at FoS from 2 hours per week for a single course to 1 hour per student per week for the same course. Luckily, it was manageable because we only had 20 students enrolled in the course, but we assume that teachers with much higher loads (higher number of enrolled students and/or number of courses) had even less free time for content and learning management done in a satisfactory way.

Thus, the goal of this paper is to report our experiences using e-learning systems during the COVID-19 lockdown, which is still taking place, to shed light on the major problems within those systems and set the stage for future research based on those observations.

4. References

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