IT-REX — A Vision for a Gamified e-Learning Platform for the First Semesters of Computer Science Courses

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Abstract: Digital learning is becoming increasingly important, especially in situations when students cannot attend presence lectures as we experienced during the Covid-19 pandemic. However, while there are platforms that support generic learning concepts such as multiple-choice questions, we believe that the first semesters of computer science courses can benefit from tailored learning platforms that support IT-specific learning. For example, programming tasks that are automatically checked for correctness. Moreover, in times when students cannot meet each other, self-organization and motivation quickly become severe problems. Therefore, this paper presents a vision for a gamified e-Learning platform specialized for the first semesters of computer science courses.

Keywords: e-Learning; Gamification in education; Study Beginners; Computer Science

1 Introduction, Motivation, and Research Questions

Due to the Covid-19 pandemic and the resulting need for staying at home, digital teaching and asynchronous learning are becoming increasingly important since students have to learn from anywhere. Especially, in 2020 around 1.39 billion students stayed at home [UN]. While there are many e-Learning platforms available, there is currently no platform specialized in higher-level education for computer science courses of the first semesters. However, the first semester is crucial for study beginners because students often are not used to the vast amount of content to learn in only a short period. Moreover, especially this content creates the foundation for further semesters. While many e-learning platforms such as ILIAS or Moodle offer plugins for structuring content or writing and checking source code, lecturers often do not instrument them in their full capacity as their usability often lacks an easy-to-use interface. Additionally, many student beginners have challenges to be *intrinsically motivated* for learning new content regularly, especially if the tasks do not arouse interest which plays a vital role in the motivation of a learner [De97]. In particular, when lecture recordings are only uploaded without further structure, traditional platforms fail to keep students engaged in learning new content regularly instead of forcing themselves through the content just before the exam. Since intrinsic motivation is crucial to students who are responsible for their own learning [FKY18], an e-learning platform needs to *extrinsically motivate* students in this asynchronous setting which leads to our first research question:

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RQ1: *"How can an e-learning platform for asynchronous learning extrinsically motivate students to learn regularly new computer science content in the first semesters?"*

Furthermore, if students fail to intrinsically motivate themselves to repeat previously learned topics, they often do not practice content they do not master well. Instead, they often tend to concentrate only on learning new content without practising old content in full depth. As a result, such students often tend to forget the content they learned before. Therefore, we need to extrinsically motivate students to repeat old learning content regularly, concentrating on concepts they do not master well. This leads us to our second research question:

RQ2: *"How can an e-learning platform extrinsically motivate students to regularly repeat previously learned computer science content in the first semesters?"*

In this paper, we present a vision for an interactive e-learning platform tailored for the first semesters of computer science courses in order to keep them motivated and to support social interactions. The platform is organized around a gamification approach that aims to motivate students in learning, repeating, and practising learned knowledge while keeping them engaged in their studies and offering social interaction.

2 Vision for a Digital Learning Platform Tailored for the First Semesters of Computer Science Courses

In this section, we introduce our vision for the gamified e-learning platform *IT-REX*. Our vision is to motivate students by challenging them with tasks specialized for the individual content of computer science courses in the first semesters. Therefore, in IT-REX, students have to solve computer science-specific tasks to deepen their knowledge and experience in the respective content, e.g., programming tasks, diagram drawing tasks, etc. While identifying and defining appropriate tasks for realizing learning concepts and resolving open learning fields is a mandatory building block for our e-learning platform IT-REX, this does not necessarily motivate students to regularly learn and repeat new and old content. Therefore, we use gamification as second approach in combination with computer science-specific tasks, which is an emerging trend in education [Sa15] to motivate and engage students [KAY14; Mu11]. Since there has been a lot of research done on how *gamification in education* improves the quality of learning of students [Su14], in our opinion, combining course-specific learning with gamification approaches is an important aspect for extrinsic motivation. Furthermore, gamification supports students in their goal setting [BHH20], emphasizes learning, and improves knowledge understanding [Co13]. As a single type of task does not apply well for various different learning goals and concepts, IT-REX must be tailored towards different types of computer science learning concepts and goals. Thus, we must first derive the concepts and goals relevant to first-semester computer science courses.

Learning Concepts That Need to be Supported by the IT-REX Platform We analyzed several first semester lectures of different computer science study programs and found that the following four types of courses are essential in most programs: (i) programming, (ii) software engineering, (iii) theoretical computer science, and (iv) mathematics. Each of these types of courses consists of several learning concepts, e.g., inheritance in object orientation. Furthermore, each learning concept can have multiple learning goals, for example, "The student knows the concept and can explain it", or "The student can apply the concept". Depending on the concept and goal, different types of gamification have to be supported by the platform. Since there are already well-established platforms for mathematics, we will not look further into mathematics and concentrate on teaching programming, data structures, algorithms, software engineering, and theoretical computer science.

On an abstract level, all learning concepts of a regular programming introductory lecture relate to learning how to read, write, and explain source code. Moreover, typically basic programming paradigms necessary for this are introduced, source code quality is discussed, and modelling software is practised. To test the basic understanding of programming and program paradigms, it makes sense to create single-choice and multiple-choice quizzes, assignment questions, cloze texts, etc. They can be automatically checked and, therefore, offer fast feedback to the student. However, learning to write source code is more difficult as programming is only taught well through practice. Thus, we need a means to enable students to program and to check their code for functional correctness and code quality automatically. To automatically check the source code, we plan to integrate software such as ArTEMIS[2] by Krusche et al., which enables to check in source code via git and run unit tests on it for individual feedback to the student. In case the lecture focuses on data structures and algorithms, already many game-like challenges are available online, e.g., Hackerrank[3], which can be used to improve the training in those concepts. We will integrate such tools in IT-REX. Besides understanding and writing source code, modelling software is also a crucial part of every introductory programming course. Thus, drawing diagrams and testing them automatically has to be supported by IT-REX, too. Moreover, theoretical computer science must be included, for example, by a task in which the students have to evaluate first-order logic formulas that are then automatically checked for correctness.

Gamification of Higher-level Computer Science Education in the First Semesters

Based on the identified types of tasks, learning concepts, and learning goals relevant to study beginners in computer science, we envision the following concept for gamification in our e-learning platform IT-REX. Gamification is the central aspect of the learning platform as it is intended to create an incentive for students to learn, thus, extrinsically motivating them. In our platform, comparable to a Tamagotchi in the late 90s, the students need to take care of an IT-REX, a dinosaur-like character. The IT-REX grows with increasing progress within a course and gives an impression of the overall learning progress by solving quizzes and other types of tests. Furthermore, students can compare their IT-REX with others resulting

[2] `https://github.com/ls1intum/Artemis`
[3] `https://www.hackerrank.com/`

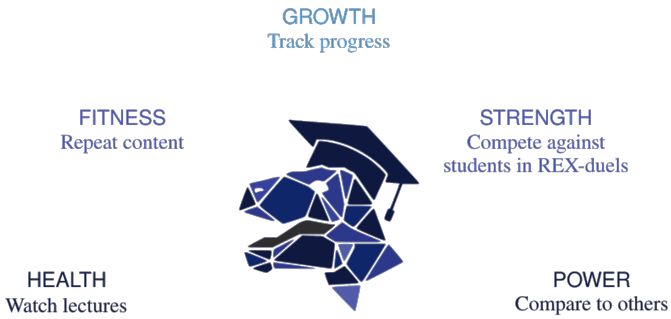

Fig. 1: IT-REX features and their objectives.

in a competition incentive. As tests, there are single-choice, multiple-choice, cloze text, arrangement questions, and more—as described in the previous Sect. 2. The lecturer must create the test questions and answers and link the test to its reflected learning goal. Students have to take tests to unlock the following content of the course. Furthermore, there are tests to repeat previous contents. By solving the tests, the students can get points for a scoreboard to compare with others. Similar to the language app Memrise, we will add a turbo mode in which the students have to solve as many tests as possible in a short period with a limited number of mistakes, thus, resulting in pressure and improving their skills under time which is also a good practice for exams. As some students do not feel well under pressure, the turbo mode is optional and, therefore, not needed to take care of an IT-REX. However, the points and benefits for the IT-REX are increased significantly in turbo mode to motivate even outstanding students to practice already learned course contents again. These concepts seem to be appropriate to motivate students for individual learning regularly.

Besides the comparison with other students on a scoreboard, a major gamification concept of the platform are *REX-Duels*. A REX-Duel is a game in which two or more students can compete against each other alone or as teams in terms of solving tasks. This duel is used for a more direct competition incentive and social interaction. It also includes the types of tasks explained in Sect. 2, which must be solved against each other in time. Furthermore, REX-Duels can contain programming tasks which are checked automatically through ArTEMIS. Through CodeTogether, the students can voice chat and collaborate on the same code base before pushing it to ArTEMIS. Accordingly, the IT-REX of the winner or winning teams receive a reward for the victory, but all students improve their knowledge.

Based on a students' progress, different features of their IT-REX representing the learning status of each student are improved. These features are shown conceptually in Fig. 1. In total, five features will be supported: (i) *Health* shows the current learning progress of a student. If the IT-REX is doing poorly, this is the indicator that the student is lagging behind. (ii) *Fitness* shows how well a student repeats previous chapters. For example, if the IT-REX is limp, the student has to repeat old chapters and "train" so that the fitness increases. Furthermore, tests that the student did not solve correctly are repeated more frequently. (iii) *Growth* serves as

a progress bar, so the students know how much of the course is still ahead of them. The IT-REX receives food with each new concept learned. Therefore, it grows and moves up in levels. An upper limit for the levels indicates the end of the course that the student is aiming for. (iv) *Strength* is used to enforce a certain level of interaction between the students and aims at motivating them to participate regularly in REX-Duels: By participating in REX-Duels, the IT-REX gets strength points that depict how a student's knowledge level is compared to others. While both participants increase their IT-REX' strength points in a REX-Duel, the winner will gain significantly more strength points which aims at motivating students to prepare for REX-Duels by learning regularly. (v) *Power* shows the composite value of the other properties so that a ranking of students can be created.

By solving tests correctly and winning REX-duels, the students additionally gain *coins* that can be used to buy things in a virtual shop, e.g., to change the appearance of their IT-REX by purchasing visual aspects such as costumes, accessories, and other elements.

3 Related Work

IT-REX combines various features of well-established e-learning platforms. For example, Udemy or Microsoft Learn courses offer their content structured in chapters or modules. The actual content can be videos, texts, or tasks. Microsoft Learn concludes each module with a learning level quiz that must be passed to complete the module — thus, these are concepts that of course make also sense to be supported by IT-REX. In particular, the gamification aspects in quiz applications are significant for the extrinsic motivation of students [Ra20]. Especially apps for learning foreign languages, such as Memrise or Lingodeer, often rely on gamification to motivate their learners. However, such language apps concentrate primarily on enforcing regular repetition through their gamification aspects instead of motivating also to learn new chapters. For example, in an earlier version of Memrise, learning and repeating vocabulary let an alien grow, similar to our IT-REX concept. Moreover, in Memrise each vocabulary has a plant which dries without regular repetition which motivates learner to do so. Incorrectly answered tasks must be repeated more quickly, which is of course also an appropriate concept to be integrated in IT-REX as this directly supports learners in precisely practicing content. As a result, many of these apps focus mainly on single dimensions, while IT-REX supports multiple dimensions of learning simultaneously. Furthermore, points to be achieved, increasing difficulty levels, and avatar constructions can also contribute to extrinsic motivation through gamification [Ra20], which has been shown by various apps. Therefore, in IT-REX, students can change the visual aspects of their IT-REX via coins.

4 Conclusions & Future Work

The presented ideas tailored for practising computer science content such as programming and data structure design could significantly help students to deepen their understanding.

Moreover, the presented ideas of gamification should support (i) regularly learning as the health status of the IT-REX, which represents the own learning progress, is directly shown on the platform. In addition, (ii) REX-Duels should also additionally improve interaction with other students. Both parts might help motivate students, which could result in better education. We plan to realize these concepts based on our already implemented basic platform for IT-REX[4] in the future. Moreover, we plan a detailed evaluation on our first-semester programming course to design and improve the platform optimally.

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