RuleCraft: an End-User Development Hub for Education

Margherita Andrao*
Federica Gini*
margherita.andrao@unitn.it
federica.gini@unitn.it
University of Trento and Fondazione Bruno Kessler
Trento, Italy

Davide Frageri
University of Trento
Trento, Italy
davide.frageri@studenti.unitn.it

Antonio Bucchiarone
Fondazione Bruno Kessler
Trento, Italy
bucchiarone@fbk.eu

Alessandro Cappelletti
Fondazione Bruno Kessler
Trento, Italy
cappelle@fbk.eu

Barbara Treccani
University of Trento
Trento, Italy
barabara.treccani@unitn.it

Massimo Zancanaro
University of Trento and Fondazione Bruno Kessler
Trento, Italy
massimo.zancanaro@unitn.it

ABSTRACT

Personalized learning methods have revolutionized education by allowing tailored teaching approaches to meet individual students' needs. This approach, supported by educational technologies, aims to engage learners with diverse expertise levels by adapting content and methods accordingly. This demo introduces an End-User Development system that empowers teachers to create and define interactive behaviors of educational tools using Trigger-Action Programming (TAP). The system facilitates the creation of "vocabularies" specific to each learning subject and translates them into verbal primitives for trigger-action rule definition. These rules are then used in the customization of interfaces. This demo presents examples using a tangible device and a web-based educational game aimed to enrich education activities in elementary schools. Future directions include studying teachers' appropriation of the use of TAP to customize learning material as well as adaptation in new domains and with different devices.

CCS CONCEPTS

• **Human-centered computing** → **Interaction devices**.

KEYWORDS

End-User Development, Tailored Gamification, Tangible, Internet of Things, Phygital

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*Both authors contributed equally to this research.

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1 INTRODUCTION

Personalized learning consists of allowing students and teachers to select materials according to individual needs. This approach tailors teaching methods to suit the unique requirements, abilities, and interests of students to motivate and engage learners with different levels of expertise [23, 27]. In the application of different educational technologies, a lot of efforts have been made to personalize curricula [1, 6, 7, 21, 26, 29]. In Massive Open Online Courses, for example, the automatic personalization of learning paths (e.g., [1]) has been adopted to cater to large numbers of learners. On the other hand, in smaller contexts like elementary schools, teachers play a crucial role in customizing educational tools. Since they are the primary experts in the educational field, teachers should be able to directly modify/program educational smart devices to create purpose-specific environments and integrate these devices optimally into education strategies and plans [33, 34].

In school environments, the use of smart devices, including the Internet of Things (IoT), is gaining traction due to their potential to enhance different aspects of teaching and learning [24]. Interactive educational devices have been developed for diverse subjects such as music, math, and language (e.g., [3, 14, 32]), providing engaging learning environments [2, 19]. Another way to enhance students' engagement and motivation in the learning process is gamification [18, 22] – defined as the utilization of game elements in non-leisure contexts [10]. Customizing smart tools and gameful systems may contribute to their effectiveness in educational settings [16, 22, 33]. Approaches like End-User Development (EUD; [17]) enable teachers to specialize the functionalities of educational technologies [31]. Through Trigger-Action Programming (TAP), non-programmer users can create rules specifying actions to take upon certain events [30]. TAP is considered an accessible and intuitive way to program digital technologies, reflecting the principle in computational logic that specific actions are necessary in particular situations [11].

This demo presents RuleCraft a system that enables teachers to create and define new interactive behaviors for multiple educational tools across various school subjects. The system was first designed

to support the use of an EUD interface based on TAP, created to connect the definition of the behavior of a tangible educational tool with gamification [5]. Our system additionally supports the upload of multiple vocabularies, allowing other domain experts to create and upload learning material to extend the EUD solution to different topics and subjects.

2 THE SYSTEM: RULECRAFT

RuleCraft (see Figure 1) is an existing platform for *domain experts* to craft and refine *vocabularies* tailored to specific learning domains (e.g., maths), including motivational aspects (i.e., game elements). Domain experts can be represented for example by researchers, developers, or educators who are interested in developing a new set of *verbal primitives* for innovative EUD educational tools. By verbal primitives, we intend basic and understandable commands written in natural language. In our system, verbal primitives can be coded as events, states, and actions [9, 15]. The system is composed of a web app for the upload of vocabularies and the following creation of trigger-action rules. The created rules can then be used to customize the behavior of one or more interfaces. In our case scenario, the interfaces are represented by SMARTER [4] and SmartGame [13]. SMARTER is a tangible IoT device designed to support hands-on experience for elementary school children in math education while SmartGame is a gamified web app aimed at supporting the use of SMARTER in the teaching-learning process and motivating children during activities. The **Vocabulary Smith** component, built

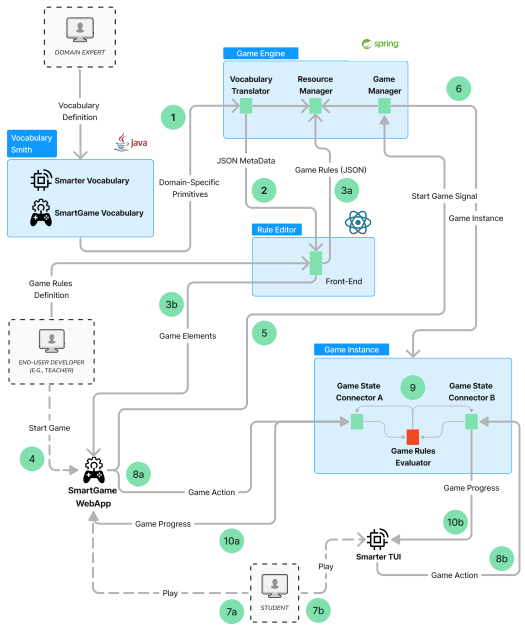

Figure 1: RuleCraft's Architecture and Flow.

in Java, is the cornerstone of the process for defining and refining vocabularies. Beyond the standard functionalities of a simple vocabulary editor, it translates these vocabularies into a set of verbal primitives (1), which are required to define the rules and game elements for specific learning tasks. These verbal primitives then find their way to the heart of the system, the Java-based **Game Engine** component, built using the Spring[1] framework. Here, the primitives are transformed into JSON metadata format by the Vocabulary Translator (2). This is a crucial step, as it paves the way for the subsequent stages of rule definition and editing. This formatted metadata serves as the backbone for the Rule Editor component, an intuitive frontend interface for end-user developers (i.e., teachers) implemented using React[2]. There, users can define rules (3a) using predefined syntax forms and constraints exploiting the available primitives and the respective game elements visualized in the final application (3b – which in our demo, is the SmartGame web app, implemented using React). Once the rules are carefully defined, they find their home in the **Resource Manager** component. At the same time, the corresponding game elements are provided to the application, ready to be used by students.

In the demo scenario, teachers leverage the SmartGame web app to initiate and configure learning tasks, defining the classes and tangible devices (SMARTER) to be utilized. They can signal the *start of the game* to the **Game Manager** (4) and (5) bringing a new *game instance* to life (6), inviting students to engage actively. Whether through the SmartGame web app interface (7a), or directly interacting with SMARTER (7b), students delve into the learning experience. *Game actions*, whether initiated through the web app (8a) or the tangible devices (8b), are swiftly intercepted by dedicated **Game State Connectors**. These connectors play a vital role in ensuring adherence to game rules checked by the **Games Rule Evaluator** component while facilitating player status progression. Upon rule evaluation (9), this provides real-time feedback signals, such as illuminating green or red lights (10b), to indicate student progress or game advancement in the web app (10a).

3 CONCLUSIONS

In the current demo, we presented RuleCraft, an innovative system that allows the definition of multiple EUD vocabularies (i.e., sets of verbal primitives that refer to specific domains) to give the opportunity to end-users (teachers and educators, potentially students too) to define the behaviors of their tools. We expect to gain valuable insights in the study of the interaction between teachers and our system (similarly to [12, 25, 35]). As pointed out by other researchers, EUD solutions can empower domain experts, like teachers, by enabling the customization of interactive systems (e.g., [28]), which in turn facilitates tailoring curricula according to students' characteristics [8, 20]. In the demo presented, we show two distinct vocabularies – that can also be used jointly – to enable elementary school teachers to customize two different tools: SMARTER – an IoT tangible tool – and SmartGame – a gamified web app – both dedicated to math education. While it has not been adopted yet in user studies, in the future we aim to explore the strengths and limitations of our system by (I) studying the interaction between educational experts (e.g., teachers, logopedists) and the Rule Editor and (II) creating vocabularies for other domains (e.g., grammar, syntax).

[1] https://spring.io/
[2] https://react.dev/

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