Realization of a Configuration Tool for a Learning- and Gaming-Analytics-Environment for an Applied Simulation in the Context of Psychology Studies

Ramona Srbecky, University of Hagen, Germany
Matthias Bürger, University of Hagen, Germany
Simon-Alexander Wetzel, University of Hagen, Germany
Wieland Fraas, University of Hagen, Germany
Jan Dettmers, University of Hagen, Germany
Matthias Hemmje, University of Hagen, Germany

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Abstract
Based on the work in our previous paper, this one describes a novel configuration tool for a work task simulation, including a gaming and learning analytics environment. A central content focus of the study module "Work and Organizational Psychology" in psychology is job design, which deals with the effect of work on the working person. The critical teaching of theoretical basics of psychological work design, which is mainly done by reading and discussing relevant theories and research results, is unfortunately mostly lacking in the experience of practical job design training during these studies. This can only be achieved by experiencing a simulated training situation, trying out job design skills, and experiencing the effects of different forms of job design. To achieve this, nine psychologically relevant work design characteristics from work content, workflow/organization, and social relations can be manipulated in the simulated work training tasks and their training context. These characteristics must be able to be configured and saved by the teacher before the simulation is played. Subsequently, the configuration must be automatically available to the students when the simulation is started. For the characteristics to be measured in the game, settings must be configured for gaming and learning analytics based on this. Finally, the paper presents the proposed configuration tool's conceptual considerations and overall concept. Furthermore, the proof-concept implementation of the tool mentioned above and the evaluation are presented. Finally, the paper concludes with a summary and the remaining challenges of the approach.

Keywords: xAPI, eXperience API, Configuration Tools, GALA4QBLM, PAGEL, HEI, Learning Analytics, Gaming Analytics, Applied Simulations, Psychology Studies, QBL, QBLM, Simulation Configuration

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1. Introduction

The research project PAGEL (Psychologische ArbeitsGestaltung ErLeben) (Fernuni Hagen LG Arbeits- and Organisationspsychologie, 2022), which is carried out in the context of work psychology (AO) at the University of Hagen (FUH) (Fernuni Hagen, 20223has the objective of making the effects of work on human health, psyche, and motivation tangible. Students in the field of industrial and organizational psychology should have the opportunity to experience these effects themselves, especially in the form of stress, using a simulation (Fernuni Hagen LG Arbeits- und Organisationspsychologie, 2022). Based on a pilot study by (Hertel et al., 2003), a web-based simulation (hereafter referred to as PAGEL simulation) for the performance of work tasks in the context of a serious game is to be realized to enable the study of these effects. A serious game generally describes an educational or game-like concept in an educational context. In contrast to pure entertainment games, serious games have a characteristic goal that is in the foreground in addition to the entertainment factor (Göbel, 2017). The pilot study of (Hertel et al., 2003) describes the re-enactment of work in a computer store, where salaried employees have to process customer orders, interact with colleagues and make decisions.

Based on these findings, this "computer store simulation" was conducted as a pilot study to further investigate this effect (Hertel et al., 2003). This idea of a "computer store simulation" will be extended in the PAGEL project to include interaction with colleagues and supervisors so that the player can receive virtual requests from colleagues and employees within the PAGEL simulation (Srbecky et al., 2022). In the PAGEL simulation, employees are supposed to have several different tools at their disposal that they can use for their work in a virtual environment modeled on the Windows operating system. The tools are deployed and communicated in a higher-level PAGEL tool (Srbecky et al., 2022). The evaluation of PAGEL simulation runs will be performed using configurable Learning Analytics and Gaming Analytics components. In this context, learning analytics describes collecting and evaluating data about learners and their learning environments to measure the extent to which intended learning goals have been achieved (Srbecky et al., 2022). Analogously, Gaming Analytics deals with collecting and evaluating data in the context of virtual games and simulations (Marks, 2022). The evaluation of the response to queries in the simulation is to be assigned to competencies to be presented collectively in the learners' personal Competence and Qualification Profile (CQP). These CQPs are stored within the QBL4Moodle (Then, 2020) system. This is an extension of the Learning Management System (LMS) Modular object-oriented dynamic learning environment (Moodle) (Moodle - Open-source learning platform | Moodle.org, o. D.) that builds on research in the department of Multimedia and Internet Applications (MMIA) at FUH (Fernuni Hagen LG MMIA, 2023) on competency-based learning management and enables integration of competency-based learning approaches into Moodle (Then, 2020). QBL4Moodle builds on the Qualifications-Based Learning Model (QBLM) (Then, 2020). The QBLM describes a machine-readable approach to managing competencies and qualifications, also known as CQs, based on skills in digital learning." (Then, 2020) Building on QBLM, gaming analytics, and learning analytics framework is to be developed in this context in the MMIA in the future in the Gaming Analytics Learning Analytics for Qualifications-Based Learning Model (GALA4QBLM) (Marks, 2022) project, which is being carried out in parallel to the PAGEL project, which will be used for the analysis and attestation of competencies, among other things (Marks, 2022). This framework is also intended to include a free text analysis component that will be used to analyze customer queries in the PAGEL simulation. These texts shall be available within an authoring tool (Srbecky et al., 2021). As already (BMAS, 2020) shows, such

simulations are ideally not performed exclusively with static game parameters since the individual results of such a simulation often depend on different parameters like the number of customer requests and the game duration. Thus, to implement this practice, a configuration tool is needed to adapt the PAGEL simulation to the user specifications.

The following Problem Statement (PS) can be derived from the objectives and motivation mentioned above. The main problem of the lack of reconfigurability can be divided into three problem areas. First, for the meaningful implementation of a web-based, it is necessary to define a set of parameters for the PAGEL simulation in advance. Currently, however, there is no way to define the parameters of the PAGEL simulation or to start a PAGEL simulation with configured parameters. Furthermore, there is no configurability of the learning objectives of the students who will perform the PAGEL simulation in the future. The aspect of learning analytics, as well as a configuration option to define the simulation goals in the context of gaming analytics. However, these three configuration options above are necessary to perform the PAGEL simulation described above. In this context, it should also be that the permissions for entering and displaying configuration data are different for teachers and students. In summary, this results in the PS1: There is no input facility to configure PAGEL simulation runs.

To allow students and teachers to run PAGEL simulations at different times with the same simulation configurations, it is necessary that configuration parameters can be stored. However, from today's point of view, there is no possibility to save and reuse simulation configurations before a game session. PS2, therefore, is that there does not exist any storage procedure to reuse configuration data of the PAGEL simulation.

The communication between the configuration tool and the PAGEL simulation should be done via a web-based user interface. Since neither the PAGEL simulation nor the configuration tool exists, there is the problem that no user interface is defined to enable an exchange of configuration data between both applications. PS3, therefore, is that currently, there is no user interface definition to use configuration data in the PAGEL simulation.

The PS mentioned above results in the following Research Questions (RQ). RQ1: "How can a software system support the input of configuration data in a configuration tool for the PAGEL simulation to meet the requirements for students and teachers?", RQ2:" How can configuration data be stored in such a software system and reused in later be reused in later PAGEL simulations?", and RQ3: "How can user interfaces be defined in such a software system between the tool and the PAGEL simulation in such a way that the configuration data of a configuration data of a game session can be provided to the PAGEL simulation?"

Based on the research methodology of (Nunamaker et al., 1990) the following Research Objectives (ROs) were derived from the RQs. RO1 is assigned to the Observation Phase (OP). This phase identifies suitable concepts and existing software tools for a configuration tool in the educational area. RO2 is assigned to the Theory Building Phase (TBP). A concept is designed that shows what system components and interfaces are needed. The System Development Phase (SDP) moves the concept into a prototype and is assigned to RO3. The result of the SDP is evaluated in the Evaluation Phase (EP) in the context of a Cognitive Walkthrough (CW) (Wilson, 2013). Finally, the EP is assigned to RO4. In this phase, all RQs are evaluated. The remainder of this paper is structured according to the ROs. This means that in the State-of-the-Art section, the OP is described. In the Conceptual Design section, the TBP is described, and the SDP phase is presented in this paper in the Proof-of-Concept

implementation section. Finally, in the Evaluation section, the EP is presented. Finally, the paper concludes with a summary and indications of future developments.

2. State of the Art

This section presents tools, user interfaces, and concepts for a configuration tool. Also, the current state of the art for the existing research software landscape at FUH at the MMIA department is shown. This section reviews specific examples of visual user interfaces in which configuration data input is provided in serious games, gaming analytics, and learning analytics.

2.1 Visual User Interfaces and Tools for the Input of Configuration Data

For the configuration of serious games, for example, there is a platform called uAdventure (Perez-Colado et al, 2017). This is a development platform primarily intended for use in the field of game development for educational purposes. uAdventure, as shown in Figure 1, was initially designed for the development of so-called "Graphic Adventure Games" (also known as Point & Click Adventures) (Perez-Colado et al, 2017). The uAdventure user interface includes an editor window that allows users to customize game settings and manage and create new games via buttons. To edit the game configuration, the user is provided with various submenus grouped by configuration type within a hierarchically designed main menu. Configuration settings can be made within these menus using input fields, buttons, and other standard control components (e-ucm, 2022).

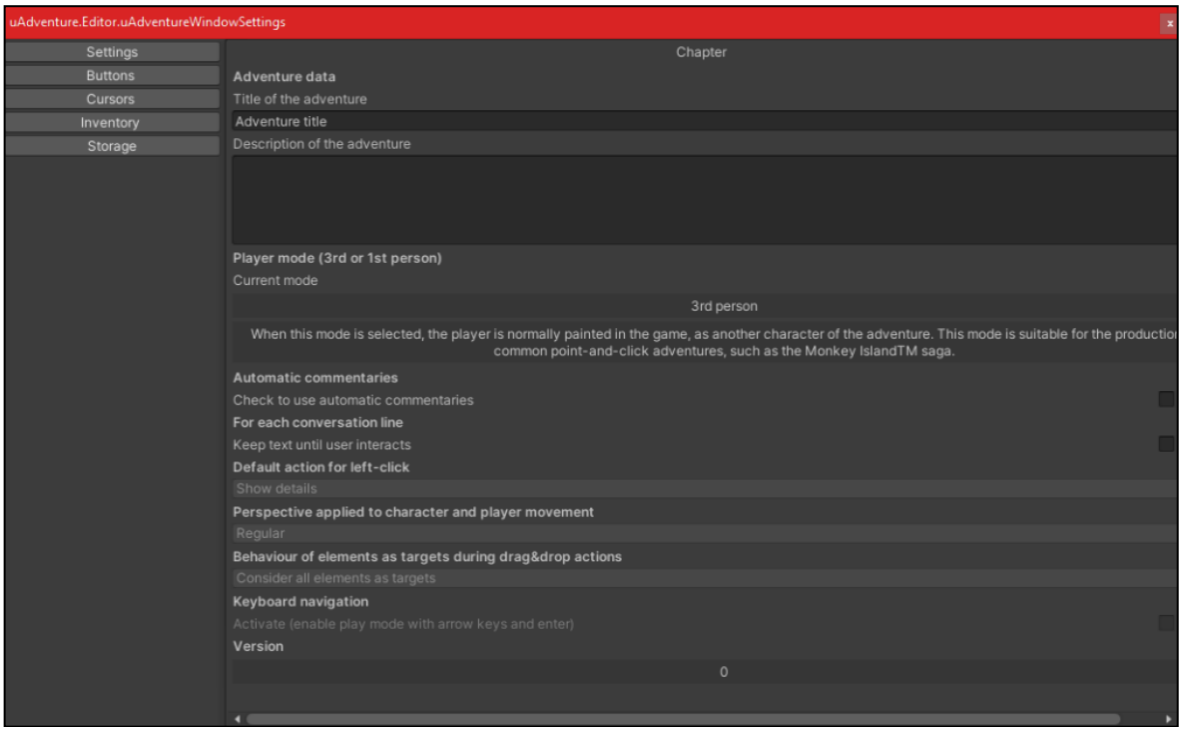

Figure 1 uAdventure menu for game settings (e-ucm, 2022)

Another example of visual user interfaces for configuring serious games is the web application Gameblox (Gameblox, 2018), a visual game editor. As shown in Figure 2, this editor uses a so-called "blocks" programming language and allows visual code blocks to be linked and combined within an editor area using a modular system. Game configurations can be adjusted directly via the visual editor. Via sidebars, it is possible to add new components

and configure existing ones. User interaction occurs via input fields, buttons, selection fields, and other controls.

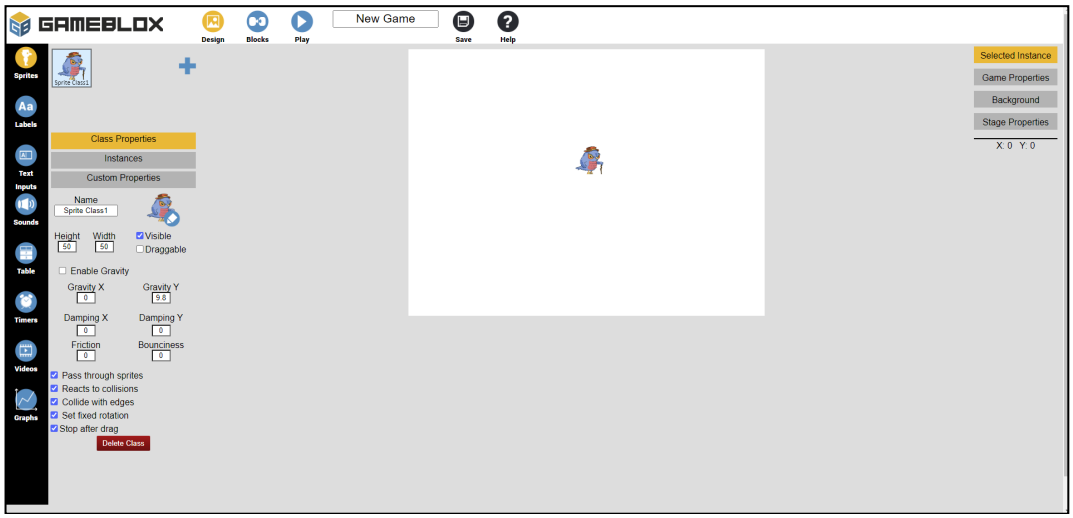

Figure 2 Screenshot of the configuration user interface of Gameblox (Gameblox, 2018)

Next, visual user interfaces in software systems from the gaming analytics environment are considered. An example of a visual user interface in gaming analytics frameworks, shown in Figure 3, is Unity Analytics, a part of the Unity Gaming Services platform (Unity, 2023). Within Unity Analytics, the configuration of Gaming Analytics parameters is done through an event manager. Visualization of recorded events takes place via a dashboard on an overview page. Users can select entries from a list of available events via drop-down menus, define recording for specific user groups and market segments, and display the resulting tracking data within a timeline. The filtered data can also be used to create various charts and reports.

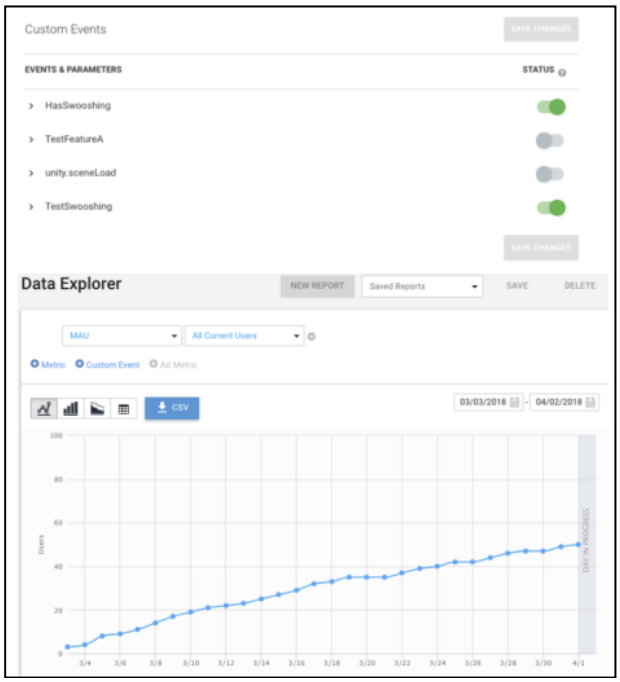

Figure 3 Screenshot of the Administration and Visualization of Gaming Analytics Parameters in Unity Analytics (Unity,2023)

As an alternative to Unity Analytics, the Unreal Engine also provides a way to collect gaming analytics data. It is possible to set up a higher-level service (Analytics Provider), which can be used to configure gaming analytics. This setup is done via an initialization file in the project directory. The required analytics provider is defined within this file and responsible for collecting the data. The events to be recorded can be configured via the user interface of a so-called Blueprint Analytics plugin (Blueprint Analytics Plugin, 2023) , shown in Figure 4. In this user interface, events can be defined within window views, with associated attribute names and attribute values, which are to be recorded. The following figure shows an example of how the equipping of a specific object in a game is recorded via a defined event (Blueprint Analytics Plugin, 2023).

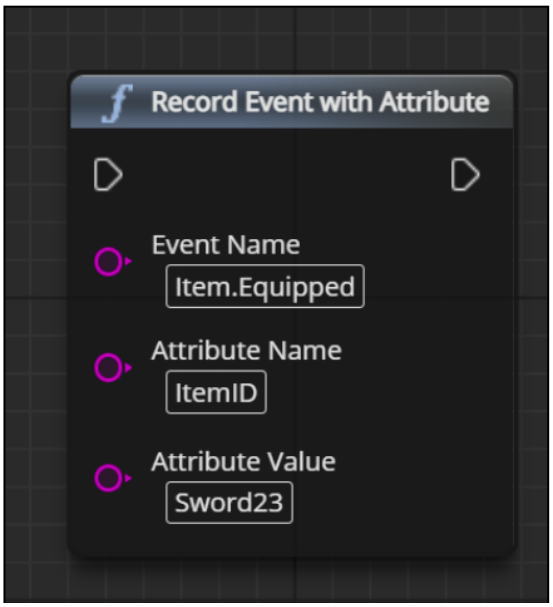

Figure 4 Screenshot of the Blueprint Analytics Plugin to track gaming analytics events (Blueprint Analytics Plugin, 2023)

In the area of Learning Analytics, the Learning Analytics interface, shown in Figure 5, available within Moodle, will be presented as an example configuration interface (Learning Analytics – Moodle Docs, o.D.).

The current configuration of learning analytics in 2022 is done in Moodle using an approach based on predictive models (Moodle, 2020). These models consist of several components, some of which are optional and configurable. In summary, these are indicators and goals to be predicted by these indicators, assessments, and notifications that are sent based on the assessments and actions suggested to the recipient of a notification. A distinction is made between static and dynamic models based on machine learning. In addition, within the Moodle Learning Analytics platform, it is also possible to use multiple models simultaneously. In addition, analytics models are managed within the administration area of Moodle in a table view. Users can make a variety of configurations related to models within the user interface. In addition to general editing of models, they can also be enabled and disabled.

Furthermore, models can be exported to Comma Separated Values (CSV) (Desai, 2021) format. Furthermore, within the user interface, it is possible to create predictions, view estimates for analyzable elements, and view evaluation and log data. This is only a simplified

overview of the current state of the Moodle Analytics user interface, as it offers many more features which will not be considered further in this research.

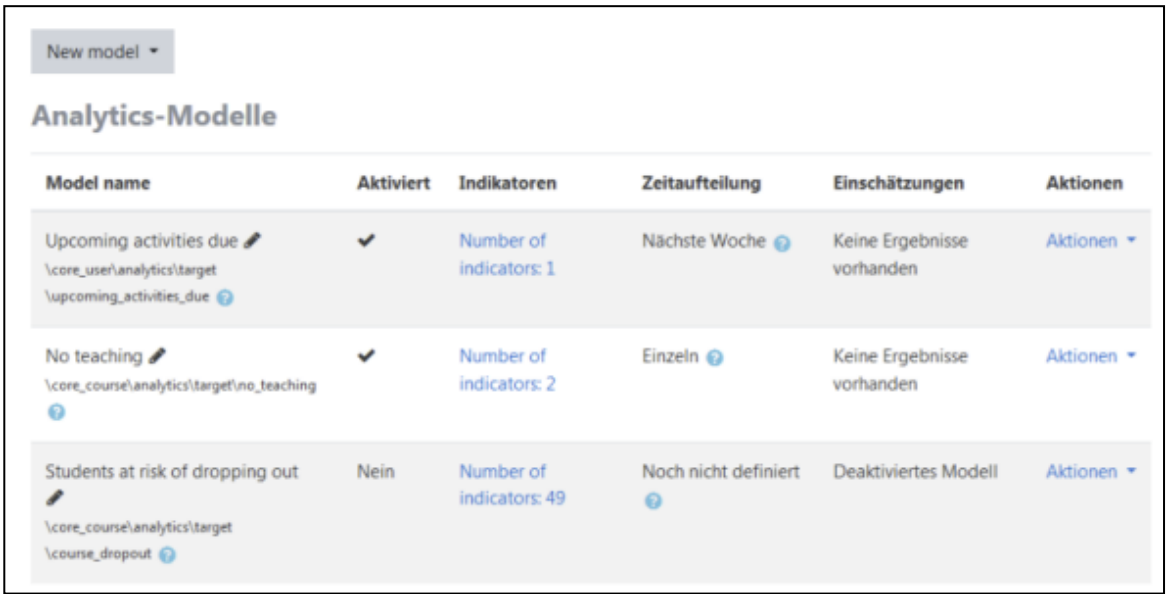

Figure 5 Screenshot of the Analytics models administration in Moodle (Moodle, 2020)

In this section, visual user interfaces and tools for the input of configuration data were considered. It should be noted that the examples considered in serious games, learning analytics, and gaming analytics predominantly follow the standard design principles of user interfaces. These principles can also be used to design the configuration tool.

2.2 Existing Tool Landscape

It is also necessary to determine the state of the art concerning the target platform in which the configuration tool will be integrated since this significantly influences which user interface technology can be used for the configuration tool. Therefore, the following section deals with the Knowledge Management Ecosystem Portal (KM-EP) (Vu, 2020) since the configuration tool will be integrated as a component within the KM-EP in the context of this research project. The KM-EP describes a knowledge management platform used to manage knowledge and scientific content within FUH (Fernuni Hagen, 2023). The portal has a web interface, is technically based on the Hypertext Preprocessor (PHP) (PHP, 2023) framework Symfony (Symfony, o.D.), and is built in a Model View Controller architecture. A MySQL (Oracle, 2023) database is used for data storage. For the provision of Representational State Transfer Application Programming Interfaces (REST APIs) (REST-APIs, 2021), the PHP Framework API Platform (Dunglas, 2023) is already used for various modules within the KM-EP, so the use of this framework for the user interface to be created for the configuration tool can be considered.

2.3 Data Communication between Configuration Tools and Web Applications

When considering user interfaces for data communication of web applications, both the transmission technology and the data format are relevant. Regarding the transmission technology of user interfaces in web applications, REST APIs are now established as a widespread standard (REST-APIs, 2021). REST APIs conform to the principles of REST architecture. These principles consist of interface unification, client-server decoupling, and

state independence (REST-APIs, 2021). This paper will use a REST API since this concept is used in the context of the KM-EP, as presented in the previous section.

In the context of e-learning, there are several interoperability standards used by different institutions and companies. In the following, some of these interoperability standards in e-learning will be considered. An overview of possible standards and concepts is provided by (Sun microsystems, 2017). According to (Sun microsystems, 2017), depending on the application area, there is a distinction between five types of interoperability standards in the e-learning environment. Concerning the superordinate task, a closer look at Content Packaging Standards seems to be reasonable because the transmission of configuration data to the PAGEL simulation is comparable to the transfer of learning resources between different learning platforms. In the area of content packaging standards, the Sharable Content Object Reference Model (SCORM) and eXperience API (xAPI) (ADL, 2023) have established themselves as widely used standards (Sun microsystems, 2017) (ADL, 2023). SCORM has been widely used in the past, but from today's point of view, it is technically less flexible and structurally designed to transfer entire courses between learning systems. Therefore efforts have been made to select a successor format for SCORM, which has resulted in the xAPI standard (ADL, 2023). The xAPI standard allows, through its open JavaScript Object Notation (JSON) (JSON, 2023) format through the use of REST APIs, the xAPI standard makes it possible to use a variety of data structures from the field of e-learning between several learning systems transfer (ADL, 2023).

3. Conceptual Design

This chapter describes the configuration tool's use cases and the relevant stakeholders. Subsequently, the concept of reaching RO2 is presented.

The PAGEL game configurations should be operable without programming knowledge within a web browser for the two user groups of teachers and students. Preliminary to the design of the user interface of the configuration tool, the most critical use cases are first mapped here using a use case diagram. The use cases include customizing, loading, and saving game configurations, starting PAGEL simulation runs, and customizing gaming analytics and learning analytics settings.

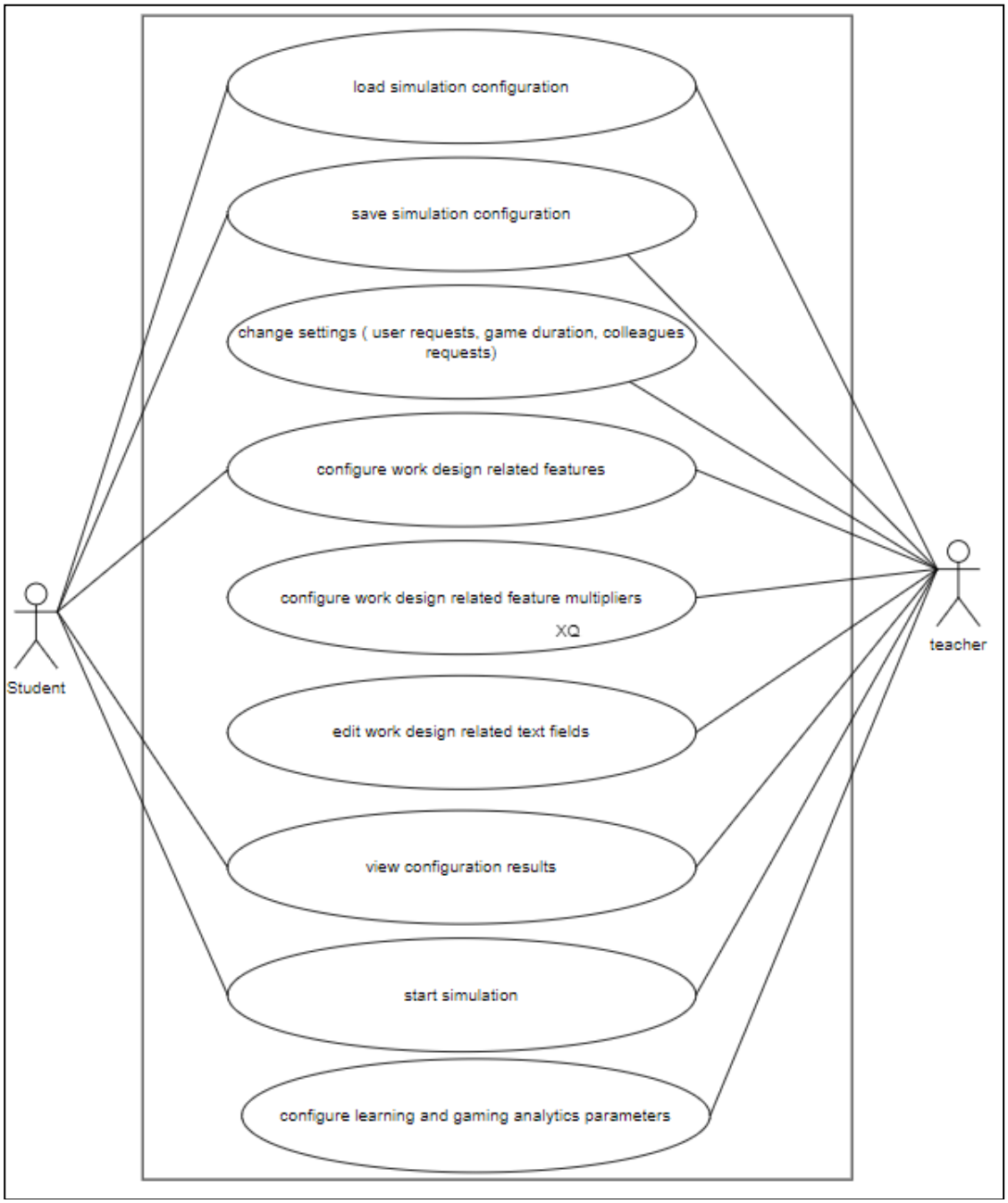

Figure 6 Use Case Diagram for the Configuration Tool with relevant Stakeholders

The use cases defined in Figure 6 will be implemented via a web-based user interface divided into three areas, shown in Figure 7, Game Settings, Learning Analytics, and Gaming Analytics. Each of these three configuration types is represented via a separate view that can be accessed via navigation buttons in the header of the user interface. For students and instructors to meaningfully run the PAGEL simulation, it is necessary to set all of the required configuration parameters for this simulation before starting the simulation. Specifically, the parameters are the duration of the game session and the number of requests a player receives from customers and colleagues via chat and email during a game session. These game parameters are to be entered via numeric input fields.

Furthermore, the setting of so-called work characteristics shall be possible via sliders, whereby these work characteristics can assume integer values between 1 and 4. The total

number of customers and colleague requests is also determined by multipliers, which teachers can adjust for some work characteristics via additional input fields. Teachers shall also have customizable text fields to describe the work characteristics. For students, only static predefined work feature texts shall be displayed, which shall not be changeable by students. Gaming Analytics settings shall be based on specified Learning Analytics learning objectives and the basis for recording student learning objective progress. In addition, the configuration tool will be integrated within the KM-EP as a new module. For this purpose, an additional menu item will be made available within the KM-EP user interface.

A unique code is generated by pressing a "Save Configuration" button, which will be displayed to the user after the saving process. Existing codes shall be able to be entered via an input field. Via a "Load configuration" button, it shall be possible to reload the saved configuration for an entered code. In addition, calculated intermediate and final results for all game-relevant parameters shall be displayed within the user interface, which results from the current game configuration and is automatically updated when the configuration is adjusted within the user interface. The PAGEL simulation shall be able to be started via the "New Game" button, which transmits the current configuration to the simulation.

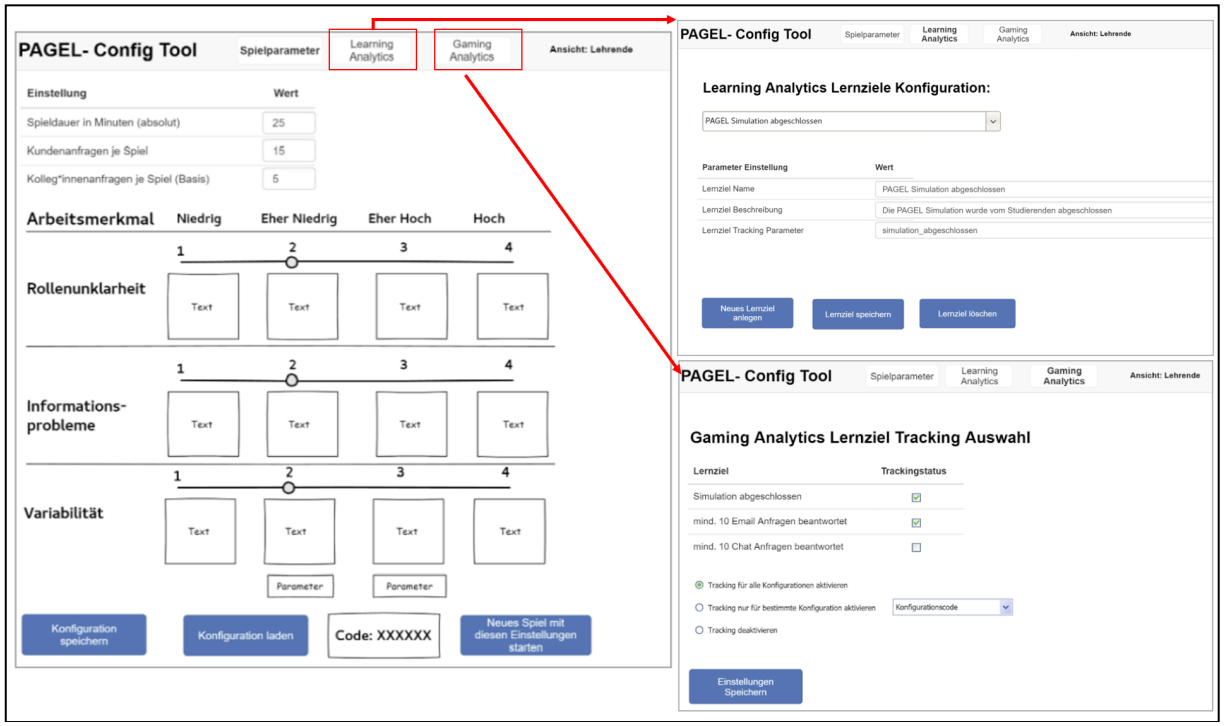

Figure 7 Concept for the User Interface of the Configuration Tool and Learning and Gaming Analytics Configuration Environment

For the data management of the configuration tool, it is necessary to conceptually extend the existing database in KM-EP with new tables. Existing tables of KM-EP do not have to be retrieved or changed. Only the table of KM-EP users is taken into account to distinguish between students and teaching users of the configuration tool. To ensure a transparent integration of the tables of the configuration tool within the existing KM-EP database structure and to visualize the relationship of the tables, all database tables newly created in this work for the configuration tool are created with the prefix pagel_. Figure 8 visualizes the data structure and the relationships of the designed tables within the configuration tool on the database level.

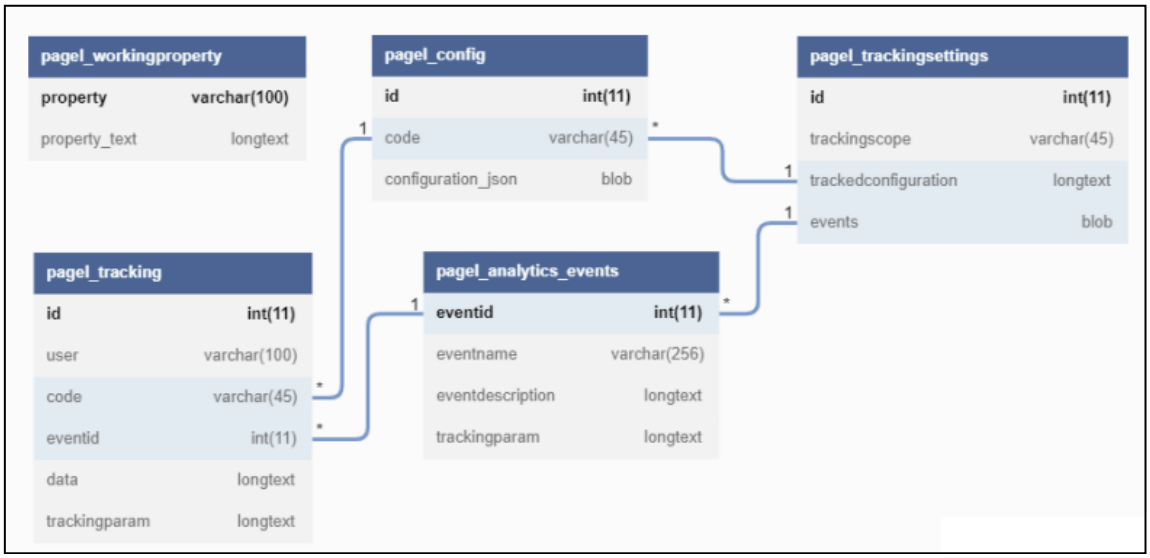

Figure 8 Database model for the configuration tool

In the following, the conception of the data management within the configuration tool is explained using this entity relationship diagram. The table pagel_config contains the list of the existing configuration data records. Each configuration record consists of a configuration code and a JSON file containing the configuration code's associated configuration data. The texts of the functional properties that teachers can store are independent of the configuration data. They are stored within the pagel_workingproperty table, which contains the working property name and the current description text. The current Gaming Analytics game settings are stored as a single record in the pagel_trackingsettings table. The list of existing learning objectives that can be tracked within the Learning Analytics configuration is stored in the pagel_analytics_events table. All tracking records associated with these learning objectives are stored within the pagel_tracking table.

The following component diagram in Figure 9 provides a simplified overview of the provision of the user interfaces for data communication of the configuration tool to the PAGEL simulation, as well as to the PAGEL analysis tool, which according to the current status of the PAGEL research work will use the provided user interface of the configuration tool.

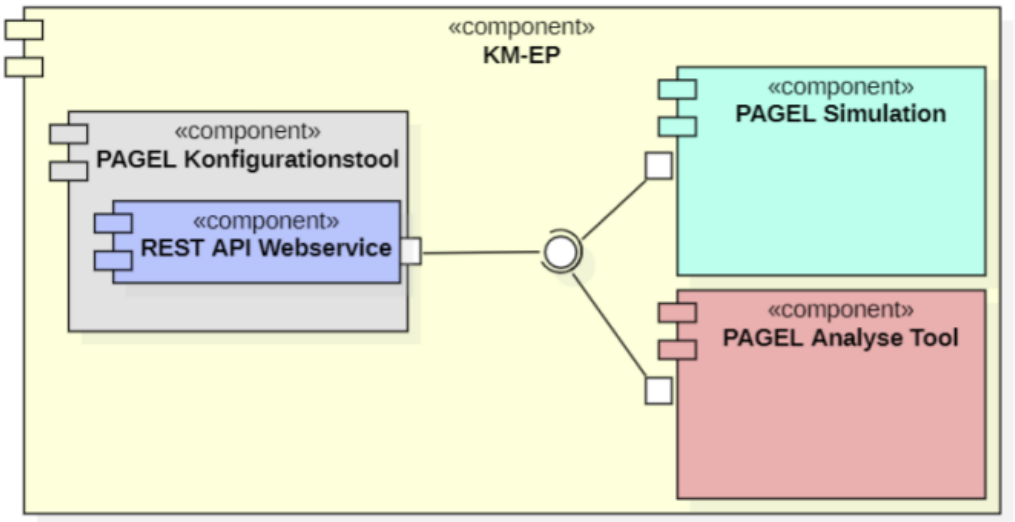

Figure 9 Component Diagram for the Interfaces between the Components of the PAGEL Simulation and the Configuration Tool

4. Proof of Concept Implementation

This chapter describes the Proof-of-Concept (PoC) implementation in the context of RO3 based on the previously described concept.

This section addresses the implementation of the configuration tool user interface within the KM-EP system. Twig templates (Symfony, 2023) were designed for all conceptualized design templates from the conceptual design following the structure of the Symfony framework used in the KM-EP. The technologies used to design the Twig templates were Hypertext Markup Language (HTML) (HTML Standard, 2023), Cascading Style Sheets (CSS) (CSS Snapshot, 2022), and JavaScript (W3C, 2016). The created user interface consists of four views for which templates were created:

- The PAGEL game configuration from a student perspective (studentconfig.html.twig)
- The PAGEL game configuration from the teacher's perspective (teacherconfig. html.twig)
- The learning analytics configuration view (learning_analytics.html.twig)
- The Gaming Analytics configuration view (gaming_analytics.html.twig)

To distinguish whether the user interface of the teachers or students, as shown in Figure 10, is displayed to a user, a check of the KM-EP user group rights takes place within the PHP controller so that only teachers can open the corresponding view. In contrast, the views for students have no restrictions in terms of accessibility, so they can also use the configuration tool even without a KM-EP user account. Furthermore, to ensure good usability of the configuration tool, confirmation dialogs have also been introduced for significant user interactions, as well as success and error messages displayed to the user within the interface.

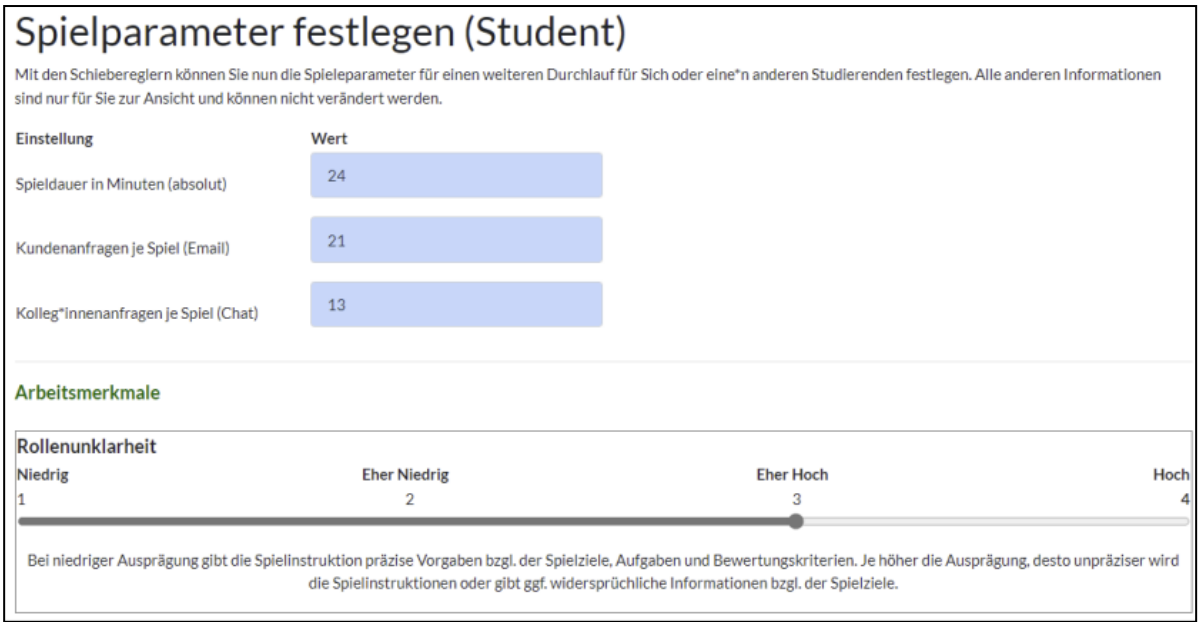

Figure 10 Screenshot of the implemented Configuration Tool in the students' view in German language

Implementing the user interface for Learning Analytics, as shown in Figure 11, the area includes all necessary input fields and buttons for intuitive creation, editing, and deletion of learning objectives.

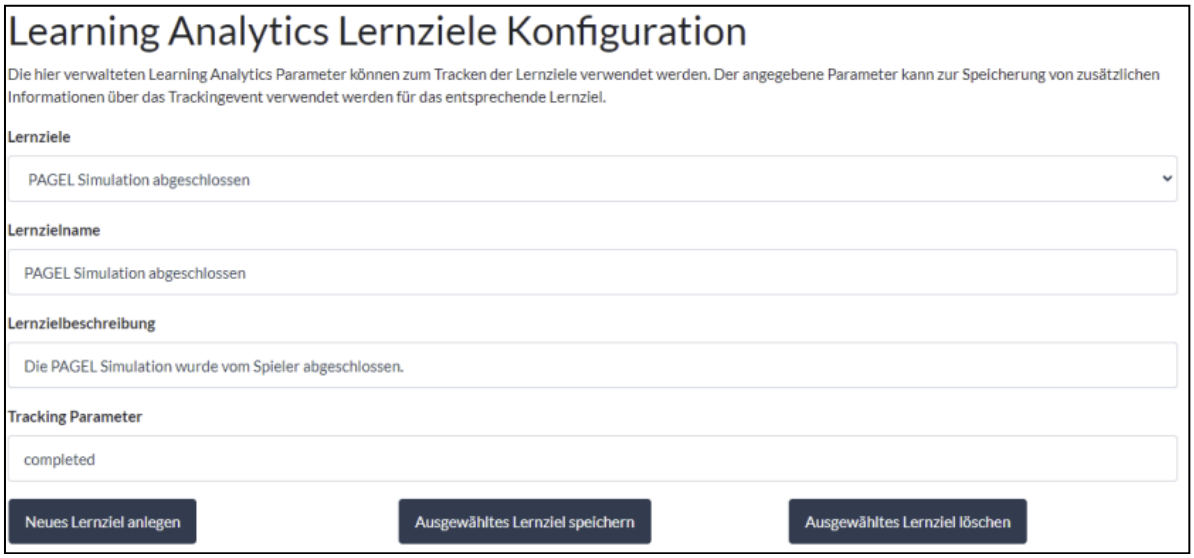

Figure 11 Screenshot of the implemented Learning Analytics Configuration User Interface in German language

Based on the design draft of the Gaming Analytics user interface created in the conceptual part, this was implemented as shown in Figure 12 within the instructor view of the configuration tool. The tracking of learning goal progress should occur to determine which learning objectives should be evaluated and in which PAGEL configuration runs. A list of all learning goals is displayed here in the selection fields.

Figure 12 Screenshot of the implemented Gaming Analytics Configuration User Interface in German language

Building on the concept of the data interfaces, the next section will present the implementation of the interfaces in KM-EP. MySQL version 5.7 was used for data storage based on the KM-EP databases. The database access of the API is done via the Doctrine Entity Manager (Doctrine, 2023) integrated with Symfony (Symfony, 2023). As the data format for returning the configuration data of the PAGEL simulation and the Learning Analytics tracking data, the JSON format was used considering the xAPI standard. Within the getApi method, called via the class annotation, the conversion of the configuration data records, which are stored within the database in the JSON format, into the xAPI standard. For this, a JSON character string is put together according to the rules of the xAPI standard, which consists of the superordinate parts "Actor", "Verb", and "Object". Within this

implementation, the "Actor" was defined symbolically as "Pagel player", as "Verb", the verb "starts" was chosen, and as "Object", the URL of the PAGEL configuration. Additionally, under "Object," there is a "Result" element, which contains the resulting configuration data, as visible in Figure 13.


```
{
  "actor": {
    "name": "PAGEL Spieler",
    "mbox": "mailto:student@fernuni-hagen.de"
  },
  "verb": {
    "id": "http://registry.tincanapi.com/#uri/verb/149",
    "display": {
      "de-DE": "startet"
    }
  },
  "object": {
    "id": "https://studev4.fernuni-hagen.de:27880/pagel/config/999999"
  },
  "result": {
    "response": {
      "game_duration": "30",
      "customer_requests": "25",
      "colleague_requests": "15",
      "result_customer_requests": "20",
      "result_colleague": "13",
      "result_comments": "7",
      "result_offers": "13"
    }
  }
```


Figure 13 Screenshot of the xAPI data from the Configuration Tool

5. Evaluation

A CW was selected as the initial evaluation methodology for this paper to reach RO4 (Wilson, 2013). This task-oriented inspection method is performed without an end user (Wilson, 2013). However, a CW can be usefully applied already in an early development state of software (Wilson, 2013).

A CW is divided into three phases (Wilson, 2013). First, the system users are described in the preparation phase, sample tasks are designed to be completed with the system under test, and possible solutions are developed (Wilson, 2013).In the analysis phase, the actual CW takes place (Wilson, 2013).In this phase, the domain expert documents each of his actions and considers possible problems real users might have with the system (Wilson, 2013). In the Follow-Up phase, identified usage problems are documented, and their causes (Wilson, 2013).In addition, possible alternatives for them are named (Wilson, 2013).

A detailed documentation of the CW can be found here (Bürger, 2022). Also, the following "Follow-Up-Phase" of a CW is documented in (Bürger, 2022) with the questions, comments, and possible future improvements and enhancements of the implementation.

6. Conclusion and Future Work

As an orientation for the future use of the configuration tool, the integration task and a test within the overall system of all PAGEL software components arise first. In particular, the functionality of the simulation start is an essential aspect that must be added to the configuration tool. In addition, the Cognitive Walkthrough, in particular, has generated a list of enhancement and improvement possibilities for the configuration tool, such as the introduction of an additional admin login for the customization of the work feature texts, as well as an assignment of the created Learning Analytics learning objectives to learning competencies. For these and other changes, one possible approach, taking into account the user-centered design concept already used in this work, is first to prioritize all adjustments by consultation within the PAGEL project team involved, as well as to evaluate and specify all requirements in more detail and finally to implement them in priority order.

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Contact email: ramona.srbecky@fernuni-hagen.de
matthias.buerger@studium.fernuni-hagen.de
simon-alexander.wetzel@fernuni-hagen.de
wieland.fraas@fernuni-hagen.de
jan.dettmers@fernuni-hagen.de
matthias.hemmje@fernuni-hagen.de