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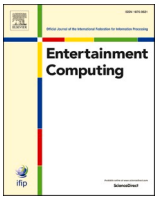

The evaluation of an educational game to promote pre-service teachers' self-regulated learning

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ABSTRACT

The present study describes the evaluation of *Regulatia*, an immersive web-based educational game for pre-service teachers to promote self-regulated learning (SRL). Based on Zimmerman's model of SRL, learners immerse themselves in the underwater kingdom *Regulatia* and must find a way back home. *Regulatia* fosters the use of SRL-specific strategies and combines game elements with learning content. In this paper, the goal is to evaluate the first functional prototype of the game, examining its usability as well as users' game experience to create a basis for an effective game in the future. The findings based on a sample of $N = 31$ pre-service teachers from a Southwestern German university indicate great usability and a good feedback system, high perceived knowledge improvement, and pleasant visual aesthetics. Potential for optimization was revealed for the scope and the level progression of the game.

1. Introduction

Self-regulated learning (SRL) is "a process whereby learners activate and sustain cognitions, affects, and behaviors that are systematically oriented towards the attainment of personal goals" [1,p.1], and is crucial for lifelong learning. It contains cognitive, metacognitive, and motivational components [2] and enhances the learning process, leading to improved academic achievement [3]. Using SRL strategies can be advantageous for university students, particularly in autonomous digital learning environments for academic courses, making SRL highly relevant in this context [4]. Especially for pre-service teachers, meaning students enrolled in teacher education programs to become future teachers, it is important to possess the necessary skills to promote SRL among their students during their studies. Pre-service teachers are a special subgroup of students which can have a huge impact as a multiplicator for SRL [5]. In the classroom, teachers can support the development of students' SRL in multiple ways, such as by direct strategy instruction or indirect promotion via learning environments that enable self-regulated learning, e.g., by prompting self-reflection [6]. As future role models, pre-service teachers will not only impart knowledge directly to their students but will also demonstrate the use of SRL strategies themselves [7]. Studies suggest that pre-service teachers often have fragmented [8], or disorganized knowledge of SRL strategies [9] and rarely use them spontaneously [10], leading to ineffective teaching of SRL strategies in the classroom. It is crucial to equip pre-service teachers with SRL knowledge to help their students develop SRL strategies.

Considering that digital games can be highly motivating [11], we developed the educational game *Regulatia* to promote SRL in pre-service teachers. Educational games are a subgroup of serious games that are defined as games "designed for purposes other than or in addition to pure entertainment" [12,p.2]. In other words, educational games are serious games that are limited to use in educational settings. To create a game design that meets users' needs, it is important to address usability issues that could negatively affect user experience [13,14]. Considering pre-service teachers' important role in educating their future students, *Regulatia* can contribute to pre-service early acquisition of adequate SRL strategies and their conveyance. As a first step, the game has to be user-friendly to be used in pre-service teacher education. Therefore, the goal of the current study is to evaluate the first functional prototype of *Regulatia* concerning usability and user experience to assess the suitability of *Regulatia* as an educational game to promote pre-service teachers' SRL.

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2. Theoretical background

2.1. Self-regulated learning

Self-regulation involves setting goals, maintaining them, monitoring them, and adapting them to changes in circumstances [15]. If someone regulates his/her learning process or uses it in an academic context, it is called self-regulated learning [16]. SRL is defined as "a process whereby learners activate and sustain cognitions, affects, and behaviors that are systematically oriented towards the attainment of personal goals" [1, p.1]. SRL is an active process that requires the use of effective SRL strategies [16]. It is a fundamental cross-curricular skill that enables students to plan, execute, and evaluate their learning process and apply this knowledge across different fields of study [17].

Process models describe SRL as a cyclical process, dividing the learning process into different phases representing the central components of self-regulation. Zimmerman's social cognitive model of SRL [15] is the basis for the educational game developed in the present study, as it considers the different components of SRL and its circular nature (see Fig. 1). The model classifies learning into three phases: forethought, performance, and self-reflection phase. During the forethought phase, learners set goals, choose appropriate learning strategies, and prepare for learning. The performance phase comprises the actual learning. During this phase, cognitive strategies, such as repetition, are used to solidify newly acquired knowledge. Moreover, volitional and motivational strategies are used to maintain the learning activity, while metacognitive strategies, such as self-monitoring, allow for an adaptation of the current learning process. In the self-reflection phase, learners evaluate their performance by comparing their forethought phase goals with their achieved results. This comparison enables them to choose effective learning strategies and eliminate ineffective ones. The successful completion and evaluation of a task impact the choice of strategies in subsequent learning processes [15].

2.2. Usability and user experience

To promote pre-service teachers' SRL, the goal of an educational game should be that learners acquire knowledge while playing. Therefore, game usability, defined as "as the degree to which a player is able to learn, control, and understand a game" [13,p. 1453], must be considered when designing and developing educational games. In other words, usability characterizes how easy it is to play the game [18]. When players start a game, the first thing they interact with is the game interface. Therefore, the game interface should be designed to provide seamless use, offering all relevant information and actions during gameplay [19]. A convenient and reliable user interface allows players to focus on gameplay instead of struggling to navigate the game.

In most definitions, game usability only focuses on game effectiveness and efficiency but does not include the perception of specific game components such as narrative, audio, or enjoyment [13]. By integrating user perception, a user-centered design is aspired, which can positively influence usability. These perceptions are often summarized under the term user experience. User experience is an umbrella term encompassing all aspects of game maintenance in a broader notion than usability does, which includes all game "interactions beyond the main functionality" [20,p. 4939] and, therefore, also considers "a person's perception […] and response […] that results from the use" [21,p. 5758].

Both constructs influence each other because usability is essential for the quality of user experience and satisfying user experience is associated with high usability [22]. Both constructs play an important role in designing and developing a successful educational game. In the present study both, usability and user experience, are hence comprised for the evaluation of the game.

2.3. Promotion of Self-Regulated learning with educational games

Studies that promote SRL with educational games are still sparse. The game *Mission with Monty* was developed to promote metacognitive monitoring ability. Sperling et al. examined $N = 224$ fifth graders regarding their metacognitive monitoring abilities before and after playing the game in comparison to a non-game control group [23]. The post-test results revealed an increase in metacognitive monitoring skills among the game group.

A popular game environment that is often used to examine the promotion of SRL in secondary education is *Crystal Island*, a game about microbiology [24]. Because students must strategically plan, carry out, and control which activities to engage in, as well as monitor their gameplay by keeping track of the evidence they have gathered, this game fosters SRL. The game's positive impact on planning and reflection on middle school students could be strengthened by Rowe and Lester who discovered a favorable correlation between the learning outcomes in a microbiology test and the students' in-game problem-solving skills [25]. Furthermore, Cloude and colleagues examined written reflections from 120 middle school students who played the game, showing that the quantity of reflections within the game positively impacts the likelihood of solving the game [26]. According to Nietfeld et al., for higher education, the use of educational games to foster SRL "is still in its infancy" [27, p. 44]. The promotion of SRL with *Crystal Island* for N=94 undergraduates was investigated by Dever et al. [28]. By using multimodal data (e.g., log files, eye-tracking, galvanic skin response) which were measured as objective indicators of SRL, they tried to deduce SRL strategies used by the participants during gameplay. The log files included

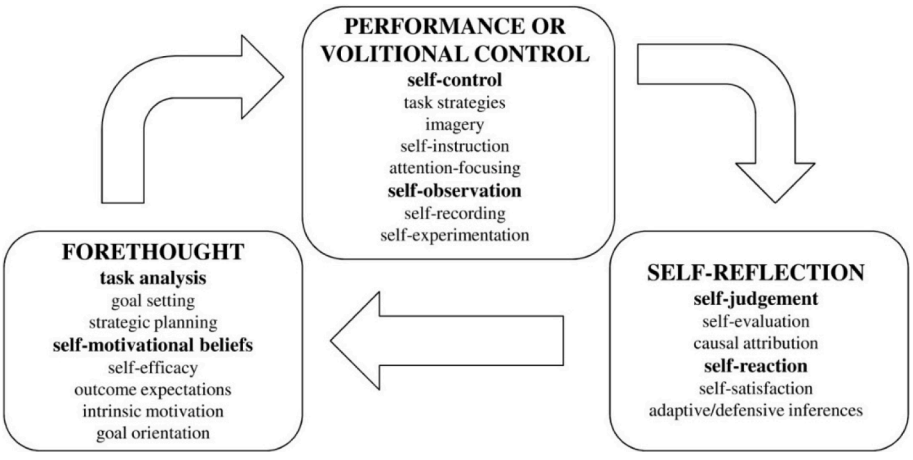

Fig. 1. Process Model of Self-Regulated Learning Note. Model adapted from Zimmerman [15].

information about the interaction with the system (e.g., clicks, navigating behavior) and eye-tracking was used to assess learning behavior via gaze position because the gaze position can be used as an indicator, for example, for cognitive load or problem-solving. The galvanic skin response was measured in the study but was not further analyzed. Participants were divided into two conditions: one group played the game with scaffolding prompts, while the other group played without scaffolding prompts. The results show that participants who received scaffolding prompts in the game exhibited greater use of SRL strategies than those who did not receive scaffolding [28].

Chen and Hsu [29] examined SRL in a virtual reality game-based learning environment regarding English learning with N=274 university students from Taiwan. SRL was assessed with self-report questions from the Motivated Strategies for Learning Questionnaire (MSLQ) before and after playing the game for two months. The findings indicate a moderate level of SRL strategies used in the game which was positively influenced by immersion and absorption ($R^2 = 0.26$). The results suggest a correlation, but do not provide any further information on the promotion of SRL with the game environment.

For in-service teachers, Persico et al. [30] created a hybrid board game, called *SRL-4Ts Game*, to prompt teachers' contemplation on enhancing students' self-regulated learning skills. The study was designed as a case study with N=15 in-service teachers from Europe. Participants' perceived competence in SRL, their SRL knowledge, and their beliefs regarding the importance of fostering SRL were measured in a pre- and posttest questionnaire. The game had a positive impact on teachers' perception of their skill in SRL, leading to a significant increase in perceived competence and SRL knowledge.

The described findings reveal a need for the development and investigation of further games for higher education to promote SRL due to the limited games and studies available. Additionally, the literature indicates a research gap in educational games for the group of pre-service teachers. Therefore, *Regulatia* was specifically developed for higher education and adapted to pre-service teachers to contribute to closing the mentioned research gap.

2.4. The present study

As the findings above show, SRL can be fostered in higher education and for in-service teachers, providing a basis for students' SRL development in the classroom and life-long learning. However, pre-service teachers, as a preliminary stage to in-service teachers, have not been considered in previous studies on promoting SRL through game-based learning. It is important to provide pre-service teachers with strategies for teaching SRL strategies during their studies in order to prevent them from having to acquire them in their professional lives later on and to prepare them for their profession in the classroom.

Due to this, the aim of the educational game *Regulatia* is to improve pre-service teachers' SRL knowledge and skills by linking theoretical learning input with playful learning. During gameplay, pre-service teachers acquire SRL strategies and learn how to teach them to their prospective students. Therefore, *Regulatia* could make important contributions to pre-service teacher training and will be the first game focusing on this special target group. To ensure the game fits to its users' needs, the present study examines three research questions: (1) Is the game perceived as user-friendly, represented through the game's usability?, (2) How do learners perceive *Regulatia*, examined through the assessment of the participants' user experience of the different game elements playability, narrative, play engrossment, enjoyment, visual aesthetics, feedback, challenge and knowledge improvement?, and (3) What are the strengths and weaknesses of the current prototype, assessed though open-ended questions regarding what the participants liked and disliked about the game?

3. Method

3.1. Sample

The evaluation aimed to assess *Regulatia*'s usability and user experience with a target user group. The study included N=31 pre-service teachers from a university located in southwestern Germany, aged between 18 and 35 years (M=22.58, SD=3.15). According to Nielson and Landauer [31] and Lewis [32], a minimum of ten to 15 users should be included in usability studies in order to identify all potential usability problems. Therefore, the sample size used in this study can be considered sufficient and was also checked with a post-hoc power analysis. On average, the participating students were in their sixth semester of studies (SD=3.93). Most participants identified as female ($n = 23$), while $n = 8$ reported a male gender identity.

3.2. Educational game

Regulatia is a web-based educational game aiming at promoting pre-service teachers' self-regulated learning. The ADDIE (Analysis, Design, Development, Implementation, Evaluation) approach was the foundation for the game's design and development process and encouraged the systematic creation of educational materials [33]. The game's theoretical content and exercises were developed based on Zimmerman's SRL model (see Chapter 2.1) and covered all three phases of self-regulation. The effectiveness of the content and exercises has already been evaluated in face-to-face training [34] and an e-learning intervention [35]. This study investigates the first functional prototype of the game, based on the theoretical design considerations which are further described in [36].

Before starting the game, players need to create an account to anonymously track their in-game performance and save progress (see Fig. 2).

The game includes six levels, each introducing a specific component of the model along with its corresponding learning strategies in the order established by Zimmerman [15] (see Table 1).

Regulatia is a learning game that uses a narrative with underwater metaphors to create an immersive experience. Immersion is "a state of deep mental involvement in which their cognitive processes (with or without sensory stimulation) cause a shift in their attentional state such that one may experience disassociation from the awareness of the physical world." [37,p. 5]. The narrative depth as well as the visual representations, such as characters and the environmental design, were implemented to support the game's immersive character. When learners start the game, they enter a mysterious vortex on vacation and find themselves in *Regulatia*'s endless ocean. They noticed that they had transformed into a whale called *Balina*. This avatar is used to create an emotional experience, aiming at the increase of learners' engagement with the game. During the introduction, the learners meet an eel that tells them about the queen of the kingdom, who is imprisoned in the *Coral Tower*. The eel suggests that the queen might know a way for the learners to get back home. To rescue the queen, the learners must earn the four pearls of self-regulation, possessed by *Regulatia*'s self-regulation keepers. To fulfill their mission, they must journey through *Regulatia* and solve the exercises of the self-regulation keepers. Each level in the game corresponds to a unique location in the kingdom of *Regulatia*. The levels are visualized on a chart, providing the learners with an overview of the game, and allowing them to orientate and track their progress for themselves because they know how many levels and exercises they have already completed and what comes next (see Fig. 3).

Short dialogues introduce the respective self-regulation keeper and the main problem that has to be solved at each level (see Fig. 4).

In level one, the targeted strategy is goal setting. The main problem at this level is that learners must prove that they are "the chosen one" to save the queen of *Regulatia*. This can be done by solving the eel's exercises regarding goal setting. In level two, the topic is time planning. The

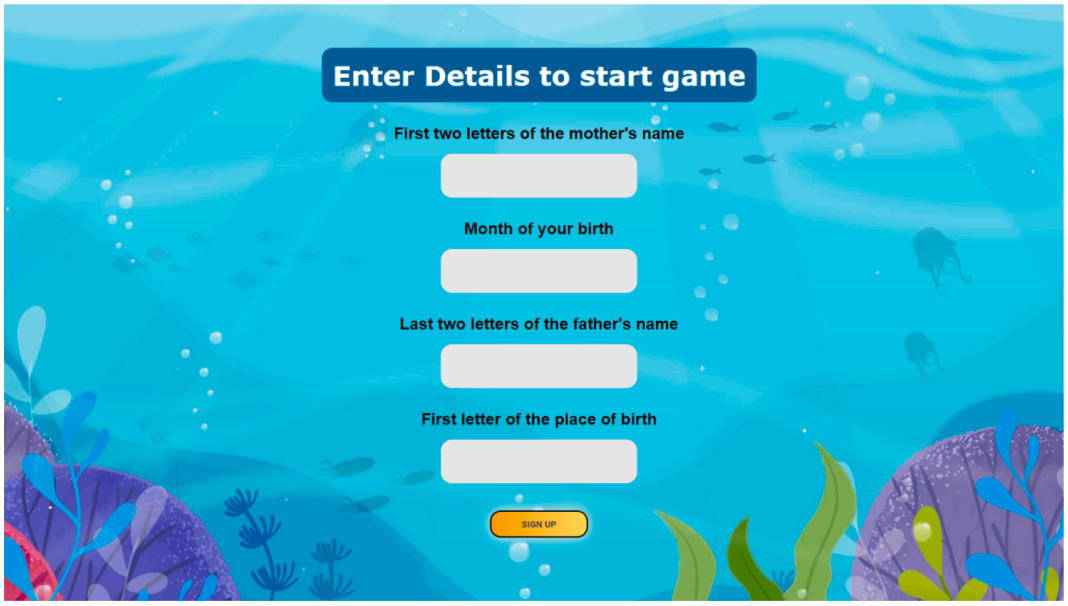

Fig. 2. Creating a User Account.

Table 1
Overview of the SRL Strategies, Game Levels, and Their Classification into SRL Phases.

SRL Phase	SRL-Strategy	Level
Forethought	Goal setting	Level 1: Endless ocean
	Time planning	Level 2: Palace of time
	Self-motivation	Level 3: Reef of self-motivation
Performance	Stress and concentration	Level 4: Cave of stress
	Learning strategies	Level 5: Garden of wisdom
Reflection	Self-reflection and causal attribution	Level 6: Coral tower

octopus *Timp*, the keeper of time, has lost his watches and asks the learners to look for them in the palace with the help of the staff. Each staff member is willing to reveal a hiding-place of a watch if the learners solve their exercise about time planning. In level three, the learners practice self-motivation by solving the four exercises of *Motus* the crab. In level four, the main problem is that the learners are too stressed to go on. *Cera*, the shark, is the cave of stress manager. Because the learners seem very stressed to her, she offers them a treatment in the cave of stress. At this level, the learners acquire different relaxation strategies. In level five, the topic is learning strategies. *Zivo*, the guardian of wisdom, asks the learners for help because *Regulatia*'s wisdom fountains need repair. Each fountain can be repaired by using specific learning strategies. In level six, *Malkia*, the queen of *Regulatia* was imprisoned in the *Coral Tower* and had enough time to think about her former life. Now she is an expert in self-reflexion and causal attribution, the process by which people reach conclusions about the causes of a behavior. She will open a portal for the learners to go home, but first, they must solve her exercises. Table 2 provides an overview of the implemented exercises at each level.

Each level contains two parts: theoretical content for the corresponding exercise and four exercises consisting of a knowledge quiz, a self-assessment exercise, and two strategy-specific tasks. Fig. 5 shows an example of a knowledge quiz and Fig. 6 presents a self-assessment exercise with the corresponding reporting. To access the exercises, learners need to read the theoretical input.

After answering the exercises, they will receive feedback indicating whether their answers were correct or not (see Fig. 7). This encourages learners to reflect on their game performance and repeat different exercises, if desired, promoting self-regulated learning beyond the initial completion of the exercises. Succeeding in the exercises is not required to progress in the game, providing learners with an environment where they can fail without fearing negative consequences. This also gives the learner the responsibility of consciously engaging in the learning content.

Upon completion of all four exercises of a level, a learner receives a pearl of self-regulation, unlocks a new level, and progresses to a new location on the chart.

3.3. Procedure

Participants were recruited through the distribution of flyers around university buildings and social media posts. Participation was voluntary, and all individuals confirmed their consent to participate. Data were collected using the *Tivian* survey platform and then anonymized by assigning individualized codes to each participant. The participants did not receive any monetary compensation; however, they were eligible to receive credit for their studies. The study was conducted in two parts.

In the first part, participants were instructed to play the game, *Regulatia*, with an emphasis on playing consciously. The instructions further clarified that they were free to explore and use all the game's functions. To receive credit, participants had to play until level two and at least 30 min. These two requirements were checked by assessing play duration and log data.

In the second part of the study, participants were given an online questionnaire to evaluate the game's usability and user experience. The survey took approximately 15 min to complete and allowed for skipping questions. The survey consisted of two parts: the first collected participants' demographic information such as gender identity, while the second presented the relevant scales related to the research questions. The following section provides a detailed description of the instruments used.

3.4. Measurement instruments

In order to evaluate the suitability of *Regulatia* as an educational game to promote pre-service teachers' SRL, usability, user experience as well as strengths and weaknesses were assessed. Usability was measured with the System Usability Scale [38] consisting of ten items. User experience was examined by using the subscales of "playability",

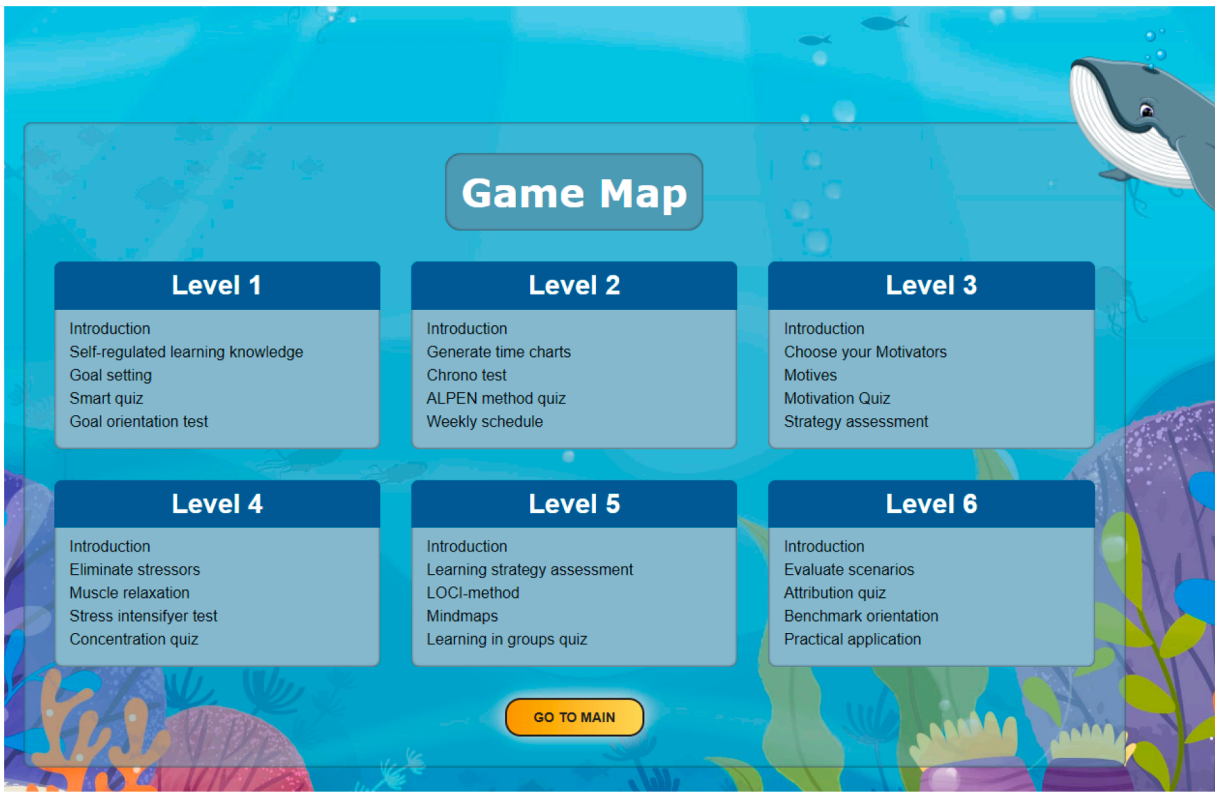

Fig. 3. Overview of the Game's Levels and Exercises.

Fig. 4. Dialogue Introducing Level Two. Note. Translation of the dialog: "Balina: Ok, these are the remains of the Palace of Time. This is where the first self-regulation keeper lives. His specialty is time planning. In the palace, time passes very quickly or very slowly. Some say there is no time at all in the Palace of Time. Others claim that time begins and ends here. Only the self-regulation keeper knows the truth.".

"narrative", "play engrossment", "enjoyment", and "visual aesthetics" used in the Game User Experience Satisfaction Scale (GUESS, [39]). These subscales examine important constructs of user experience. Playability refers to the presence of clear objectives and the intuitive use of the game interface. The "narrative" scale includes all narrative components of the game and their ability to evoke emotions. Play engrossment in a game refers to the extent it captures the player's attention whereas enjoyment is the level of delight experienced by the

Table 2
Implemented exercises in Regulatia based on Dörrenbächer et al. [34].

SRL-Strategy	Exercise	Description
Goal setting	Self-regulated learning knowledge	Multiple choice and open questions about SRL.
	Goal setting	Set three goals: a long-term goal (whole study time), a mid-term goal (whole semester), a short-term goal (whole week).
	SMART quiz	Multiple choice quiz about the SMART principles of goal setting.
	Goal orientation test	A self-test to evaluate learning goal orientation, performance goal orientation, and work avoidance orientation.
Time planning	Generate time charts	Generate three pie charts (in percent) for real time use, mental time use and ideal time use.
	Chrono test	Self-test to evaluate whether to work in the morning or evening.
	ALPEN method quiz	Multiple choice quiz about the ALPEN method of time planning.
	Weekly schedule	Plan a week using the Eisenhower Matrix (ABC classification of tasks).
Self-motivation	Motivators	Learners choose their motivators from predefined pictures and reflect on whether they are internally or externally motivated.
	Motives	Self-test to evaluate life motives that drive motivation.
	Motivation quiz	Multiple choice quiz about motivation.
	Strategy assessment	Evaluation of different self-motivation strategies from one to ten regarding their usefulness.
Stress and concentration	Eliminate stressors	Learners click on stressors in a room to eliminate them.
	Muscle relaxation	Learners listen to an audio guiding them through muscle relaxation.
	Stress intensifier test	Self-test to evaluate which stress-intensifying thoughts appear during learning.
	Concentration quiz	Multiple choice quiz about concentration strategies.
Learning strategies	Learning strategy assessment	Self-test to evaluate whether the learning strategies organizing, repeating, or elaborating are used during learning.
	Method of Loci	Using the method of Loci, a special memorizing method, to remember different indicators for water quality within five minutes in the correct order.
	Mindmaps	Creating a mindmap about the topic "The Ocean".
	Learning in groups quiz	Multiple choice quiz about learning in groups.
Self-reflection and causal attribution	Evaluate scenarios	Categorize different scenarios into attribution styles (internal/external/stable/variable), meaning the types of how persons interpret certain behaviors or situations.
	Attribution quiz	Multiple Choice quiz about causal attribution.
	Benchmark orientation	Self-test to evaluate which benchmark orientation is used when comparing one's learning success (social, individual, mixed).
	Causal attribution	Self-test which attribution style learners use to examine how they reach conclusions about the causes of a behavior or situation.

Note. SMART is an acronym for specific, measurable, achievable, relevant, and time-bound. ALPEN is an acronym for activities, length, planning, establishing priorities, noting down success levels.

player. Visual aesthetics pertains to the game's graphics and their appeal to the player. Furthermore, we added subscales for "feedback", "challenge", and "knowledge improvement" [40] to the questionnaire. All 49 items were adapted linguistically to the game, and the current sample revealed acceptable to excellent internal consistency, except for the subscale "challenge" (see Table 3). For all scales, a four-point Likert scale was used (1 = *totally disagree*, 4 = *totally agree*), and all items were translated into German.

There were three questions to ensure the study's quality. To check whether the participants played the game consciously, they were asked to rate their consciousness during gameplay honestly (1 = not conscious, 4 = very conscious). Moreover, participants' progress and game duration were recorded.

In order to evaluate the strengths and weaknesses of the prototype, the participants were given the opportunity to provide their feedback through two open-ended questions at the end of the questionnaire. The first question was, "What did you enjoy about *Regulatia*?" and the second question was "What did you dislike about *Regulatia*?".

3.5. Data analysis

SPSS (Version 28.01) was used to conduct all analyses. First, the requirements of progress and time were checked. All participants played at least until level two and at least 30 min. When asked about playing the game conscientiously, $n = 5$ people chose "very conscious", $n = 24$ chose "rather conscious" and $n = 4$ persons "not conscious". The four participants reporting an inattentive processing were excluded from the following analyses. Furthermore, the subscale "challenge" was neglected in the analyses due to its low reliability.

To examine research questions one and two, we performed descriptive analyses and one-sample *t*-tests with post-hoc power analysis to ensure the statistical procedures performed had enough power to detect the hypothesized effects. For all statistical tests, a significance level of $\alpha = 0.05$ was postulated. Regarding research question three, participants' responses were assessed qualitatively.

4. Results

4.1. Regulatia's usability and user experience

On average, participants needed 12 min to complete the questionnaire. Descriptive results of all relevant variables appear in Table 4. The descriptive data indicates high usability for Regulatia as well as moderate to high scores on all user experience subscales. To investigate the statistical significance of the descriptive results, one-sample *t*-tests were performed to determine whether the scores differed significantly from the theoretical score mean of 2.5. This was the case for "feedback", "knowledge improvement", "playability", and "visual aesthetics" but not for the subscales "narrative", "play engrossment", and "enjoyment" (see Table 4). To interpret the effect sizes, Cohen's d was calculated. According to Cohen [41], effect sizes can be interpreted as small ($d < 0.50$), medium ($0.50 \leq d < 0.80$), and large ($d \geq 0.80$), categorizing the effect sizes regarding the game's feedback as low and the ones regarding knowledge improvement, playability and visual aesthetics as high. A post-hoc power analysis for one-sample t-tests with a medium effect size of $d = 0.50$, a sample size of $n = 31$, and a significance level of $\alpha = 0.05$ revealed a statistical power of $1\text{-}\beta = 0.86$. This represents sufficient statistical power.

4.2. Strengths and weaknesses of the current Prototype?

To examine the strengths and weaknesses of the game, the answers to the open-ended questions were categorized. For the question "What did you enjoy about *Regulatia*?" we deduced eight different categories from the answers: graphical design, narration, type of knowledge imparting, learning, self-reflection, content and structure, motivation, and task

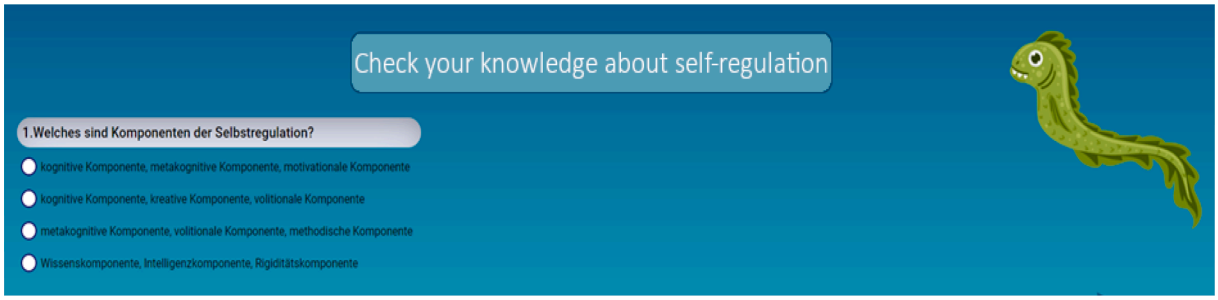

Fig. 5. Knowledge Quiz About Self-Regulation.
Note. Translation: "1. What are the components of self-regulation?
- Cognitive component, metacognitive component motivational component.
- Cognitive component, creative component, volitional component.
- Metacognitive component, volitional component, methodic component.
- Knowledge component, intelligence component, rigidity component.

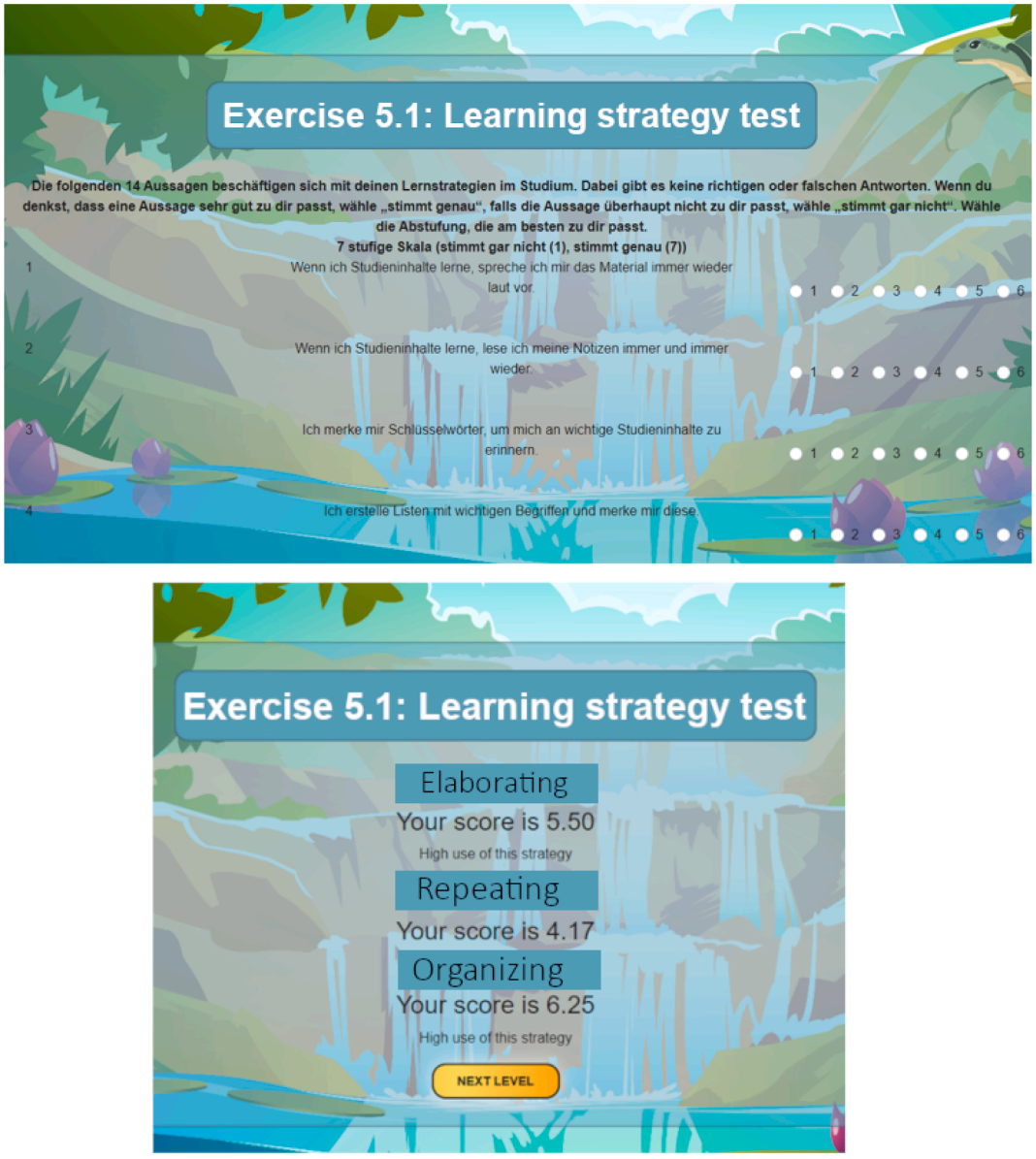

Fig. 6. Self-Assessment Exercise: Learning Style Test.. Note. Translation of the instruction: The following 14 statements deal with your learning strategies during your studies. There are no right or wrong answers. If you think that a statement suits you very well, select "exactly true", if the statement does not suit you, select "not true at all". Choose the gradation that suits you best.".

Fig. 7. In-Game Feedback for Learners Note. Translation of the instruction: “The term “saprobia” refers to organisms that live in waters with putrefactive substances. In the so-called saprobic system, these organisms are classified according to their resistance to pollution, which makes it possible to determine the water quality. Use the loci method to memorize the given saprobes and the respective water quality class in the correct order”. Presented organisms: rat-tailed maggot, river nerite, water louse, freshwater shrimp, alpine flatworm, tubificinae, glossiphonia complanate.

Table 3
Overview of the Instruments Used and Their Reliability.

Scale	Number of Items	Example	Reliability (Cronbach’s α)
System Usability Scale	10	“I found the various functions in this system were well integrated.”	0.81
Feedback	2	“I receive feedback on my progress in the game.”	0.71
Challenge	4	“The game provides new challenges with an appropriate pacing.”	0.45
Knowledge Improvement	4	“I catch the basic ideas of the knowledge taught.”	0.64
Playability	9	“I find the game’s interface to be easy to navigate.”	0.73
Narrative	7	“I am captivated by the game’s story from the beginning.”	0.83
Play Engrossment	5	“I feel detached from the outside world while playing the game.”	0.79
Enjoyment	5	“I feel detached from the outside world while playing the game.”	0.91
Visual Aesthetics	3	“I think the game is visually appealing.”	0.86

Table 4
Descriptive Statistics and Results of the One-Sample t-tests.

Scale	Min	Max	*M* (*SD*)	*t*(30)	*p*	Cohen’s*d*
System Usability Scale (SUS)	52.50	87.50	71.53 (12.04)	–	–	
Feedback	1.50	4.00	2.77 (0.60)	2.53*	0.08	0.45
Knowledge Improvement	2.00	4.00	3.02 (0.56)	5.11**	0<.001	0.92
Playability	2.22	3.89	3.16 (0.43)	8.44**	0<.001	1.52
Narrative	1.29	3.43	2.47 (0.56)	−0.25	0.401	−0.05
Play Engrossment	1.20	4.00	2.60 (0.71)	0.78	0.220	0.14
Enjoyment	1.20	4.00	2.70 (0.75)	1.51	0.071	0.27
Visual Aesthetics	1.00	4.00	3.08 (0.72)	4.43**	0<.001	0.80

Note. * = $p < 0.05$, ** = $p < 0.001$, Min = minimum, Max = maximum, *SD*=Standard deviation, Range SUS=0–100, Range user experience scales 0–4.

type.

The most frequently mentioned category ($n = 16$) and strength of *Regulatia* was the graphical design of the game, including all visual representations such as characters, graphics, and color selection (“*The graphics were appealing and created a good atmosphere.*”). The narration was mentioned four times, indicating a comprehensible storyline (“*The story behind the game is interesting and the dialog is easy to understand.*”). Moreover, five participants liked the type of knowledge imparting in the game (“*I liked the combination of gameplay and information.”).* The categories learning (“*It enables people who are visual learners to learn better and faster.*”) and content and structure (“*The division of the learning unit was well structured.*”) were deduced four times as well as the category self-reflection, indicating the participants also liked that the game encourages reflection about one’s in-game results (“*It was easy to reflect on myself, especially my diagrams and results were interesting.*“), partially unconsciously (“*You learn different content without being fully aware of it.*”). Moreover, three participants praised the motivating component caused by the combination of learning content and game elements („*A game that combines learning and fun.*“), signalizing their motivation and interest to see more of the game.. A few participants ($n = 3$) also reported that the game has a good mixture of tasks (“*I also thought the mix of tasks was great.*”). A detailed overview of all answers for the strengths and their categorization can be found in Appendix A.

For the question, “What did you dislike about *Regulatia*?“ we deduced nine different categories, representing the game’s weaknesses:

scope and complexity, graphical design, technical problems, text design, instruction, feedback, progress indicator, navigation, and task type. The most frequently mentioned category ($n = 9$) and weakness of *Regulatia* was the game's scope and complexity ("*Very extensive.*", "*The topics were very complex*."). The graphical design, which was praised as a strength by some participants was also perceived as a weakness by six participants ("*Unfortunately, I found the layout too childish and too simple.*"). Five participants have raised concerns regarding technical problems, specifically scaling problems due to varying screen sizes ("*The characters floated above the text being read.*"). Three participants indicated unsteadiness about the instructions ("*Some of the instructions were not precise*.").

As another weakness, it was mentioned five times that the game's text design could be optimized ("*There was a lot of text and the knowledge to be learned was visually difficult to read*.") and two participants expressed confusion regarding which information was relevant. The in-game feedback was also indicated as a point for improvement by three participants ("*I was missing an explanation for the wrong answers*."). Additionally, the participants expressed a desire for a level overview ($n = 3$, "*You can't see exactly how far you've progressed in the game while you're playing*.") and the ability to revisit completed levels ($n = 2$, "*You could not go back to levels that you had already played*."). Lastly, one person criticized the task type ("*I did not like the right/wrong answers.*"). A detailed overview of all answers for the weaknesses and their categorization can be found in Appendix B.

5. Discussion

The present study aimed to evaluate the usability and user experience of *Regulatia*, an immersive web-based educational game for pre-service teachers to promote self-regulated learning. The first research question was whether *Regulatia* is perceived as user-friendly. The current findings underline *Regulatia*'s usability and implicate a well-thought game design, allowing fluent gameplay.

The second and third research questions focused on user experience with *Regulatia*'s different game elements. User experience was examined by using the subscales of the GUESS [39], namely "playability", "narrative", "play engrossment", "enjoyment", and "visual aesthetics" and additional subscales for "feedback", "challenge", and "knowledge improvement" [40] as well as with open-ended feedback that was clustered into different categories.

Users' perception of the narrative, play engrossment, and enjoyment did not differ significantly from the theoretical scale mean, indicating neither a positive nor a negative experience with the game.

The non-significant result for narration could be caused by the fractional presentation of the narration during the game. The narration is interrupted by the exercises in the game which might prevent a positive effect of the narrative. Furthermore, the users only played one level of the game, so they were never presented with the whole narrative, which made it harder for them to evaluate the narrative. The perception of the narrative could have also influenced play engrossment negatively [42].

Play engrossment, the extent to which a game can capture and hold the player's attention, could be categorized as the second stage of immersion in the model by Brown and Cairns [43], involving attention and emotional connection [44]. The moderate play engrossment could be an indicator that the participants stayed in the first stage of immersion which only includes the time and effort to play the game. Therefore, the examination of only play engrossment might not have been suitable to assess the users' experience during gameplay but should rather be examined by investigating the three stages of immersion.

The results do not indicate an absence of enjoyment but room for improvement regarding this factor. Enjoyment is an important construct that increases the probability that users will play the game again [45] and should therefore be considered when creating an educational game. Game designers are often confronted with the challenge of balancing learning content, which could be perceived as boring, and motivating/fun game elements. Educational games are sometimes criticized as "chocolate-covered broccoli" (e.g., [46,47]), referring to the difficulty of linking enjoyment and learning content.

For *Regulatia*, the quantitative analysis could not reveal an enjoyment that differed significantly from the scale mean, but the qualitative analysis of the open-ended questions revealed a balance between gameplay and learning content as well as a visually satisfying appearance. This indicated a discrepancy between the two analysis methods, calling for a more detailed investigation of users' enjoyment.

As *Regulatia*'s strengths, the qualitative analysis revealed the graphical design, the narration's depth, and the type of knowledge imparting. The qualitative analysis identified the scope and complexity, technical problems, and the text design as weaknesses.

To sum up, the findings indicate that *Regulatia* is perceived as user-friendly and evokes a positive user experience which room for further investigation and adaption regarding narrative, play engrossment and enjoyment.

5.1. Limitations

The present study gives insight into users' perceptions, but limitations must be considered. One limiting factor is the sample as it only consists of persons from one German university, restricting the generalizability of the findings. Furthermore, social desirability could not be ruled out because the data relies on self-report. It could be possible that some persons did not answer the questions truthfully.

Although a check for consciousness was used, the fact that the students could receive credit for their studies could have led to alluring persons to participate who were not internally motivated to do so. In the present study, the participants took part in the study in their homes and with their own devices, enabling uncontrollable impacts from the learning environment due to the lack of a controlled lab environment. Additionally, correct answers in the exercises were not mandatory to progress within the game which leaves learners with the responsibility to solve the tasks consciously. For a future version, an overview of the task success for the teacher or a mandatory requirement could be possible to avoid misuse.

Furthermore, the current study did not consider whether the participants already had prior experience with educational games which could have impacted the current findings and could be controlled for in future studies.

Due to the low reliability of the subscale "challenge", this aspect of user experience could not be investigated which could have caused a loss of information in the current study.

Another limitation is that the current study is focused on game design and usability which does not provide insights into whether the game can promote SRL in pre-service teachers. The current findings do therefore not allow a statement about the game's effectiveness regarding the promotion of SRL.

5.2. Implications

Regulatia can be considered the first educational game prototype regarding promoting SRL for pre-service teachers. To ensure generalizability, the game should be tested with a more heterogeneous sample from different universities in Germany. An English version would be beneficial as this would minimize language barriers and would increase the scope of the game. Moreover, the volume of the content should be reviewed, and important information should be highlighted visually in the text. To improve the game regarding immersion and enjoyment, the narration should be adapted to make the story more engaging. Future studies could examine *Regulatia*'s other levels which were neglected due to time constraint considerations. This would allow prospective participants to evaluate the game as a whole and to investigate the whole narrative of the game. Moreover, future work should be conducted in a

lab environment to ensure a controlled environment to avoid confounding factors that could occur in the home environment. As a control variable, participants' prior experience with educational games could be assessed to control for potential biases.

Due to the lack of insight into the game's effectiveness, future work should involve the examination of *Regulatia*'s effectiveness regarding learning outcomes by using a randomized pre-post-control-design and the comparison to other formats of digital learning, for example, e-learning courses.

After evaluating the whole game and its effectiveness, as a practical implication, *Regulatia* could be used in teaching pre-service teachers at university to foster the quality of teacher education and to offer a different method to convey knowledge. Well-educated teachers will impact generations of pupils during their work, inspire them, and contribute to a high education level in the future.

6. Conclusion

Although the examination of *Regulatia*'s first functional prototype is at an early stage, the study showed that the current version of *Regulatia* is easy to use and positively perceived by the users overall, but there is still room for improvement regarding the narration, motivating elements and the in-game texts. The current study provides first positive insights into *Regulatia*'s usability which should be tested for the whole game in the future and also with regard to the game's effectiveness to promote SRL in pre-service teachers.

CRediT authorship contribution statement

Nathalie Barz: Writing – review & editing, Writing – original draft, Visualization, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Manuela Benick:** Writing – review & editing, Supervision. **Laura Dörrenbächer-Ulrich:** Writing – review & editing, Supervision, Resources. **Franziska Perels:** Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Appendix A

Assessment of Regulatia's strengths.
Instruction: "What did you enjoy about *Regulatia*?".

Category	Number of mentions	Participant number	Statement
Graphical design	16	1	The graphic representations.
		3	The look was very appealing and beautifully designed.
		6	The graphics.
		8	The presentation of the game.
		9	The choice of colors was also very nice.
		13	The graphics are great, the controls are simple and clearly visible.
		17	Beautiful graphics, very colorful.
		20	The design of the game is very appealing.
		21	The graphics were very appealing and created a good atmosphere.
		22	The graphics.
		24	Lots of colorful pictures and a simple layout.
		26	The font was easy to read, the color selection was appealing, and the character design was very nice.
		27	The layout and the characters.
		28	I think the graphics were designed appealingly, so it would be nice to see more.
		29	The identification characters and the graphics.
		30	The design of the game.
Narration	6	15	The game is well embedded in a story.
		19	The idea of the underwater world and the story of helping the little mermaid to reach her goal.
		21	The story was very appealing and created a good atmosphere. I also liked the fact that the player has a mission to fulfill, which you get closer to as you play through the levels.
		25	The story behind the game is interesting and the dialog is easy to understand.
		27	I liked the story behind it.
		29	The mixture of learning content and the narration.
Type of knowledge imparting	5	9	Imparting knowledge through games is very appealing.
		13	Gamification is always great and relevant information is provided for students. 9/10 points!
		27	The combination of gameplay and information.
		29	The content of the course is taught in a fun way.
		30	Psychological information in an appealing way.
Learning	4	2	I really like the idea of creating a game that covers the subject matter of educational science. It enables people who are visual learners to learn better and faster.
		14	The knowledge learned, which was tested, could be internalized.
		20	The guidance through the game itself is also very simple and you learn different content without being fully aware of it.
		22	I liked the interactive learning.

(*continued on next page*)

(*continued*)

Category	Number of mentions	Participant number	Statement
Self-Reflection	4	4	The amount of information and that you could think about it yourself.
		12	The opportunity to learn a lot about yourself.
		25	It was a good opportunity for self-reflection, and I found the diagrams about myself very interesting.
		30	I liked the self-learning effects.
Content & structure	4	7	I liked the learning content.
		12	The different subject areas.
		18	The input was very good – the best thing would be to take what can be learned with you – perhaps that can still be implemented.
		14	The division of the learning units was well structured.
Motivation	3	10	Learning psychological topics in a playful way is always a good motivation. I think this kind of motivation is well implemented.
		11	I like the idea of improving learning because I have problems motivating myself to learn.
		31	A game that combines learning and fun.
Task type	2	15	I liked that there was little open response format.
		20	I also thought the mix of tasks was great.

Appendix B

Assessment of Regulatia's weaknesses.
Instruction: "What did you dislike about *Regulatia*?".

Category	Number of mentions	Participantnumber	Statement
Scope and complexity	9	2	I also found that the information led to a sensory overload.
		7	Very extensive.
		8	It was not clear to me exactly what information would be relevant in the following. It is therefore difficult to memorize the details in such a short time.
		15	There is a lot of irrelevant text.
		16	Lots of unnecessary information at the beginning, imparting knowledge that was not tested in any way afterward.
		17	There is a lot of irrelevant information.
		22	The game was very long.
		24	The topics were very complex.
		30	I did not like the (sometimes) complicated content.
Graphical design	6	1	The embedding is not very authentic.
		2	Unfortunately, I found the layout too childish and too simple. It would have been nice if the graphics had been more sophisticated, e.g. with animations.
		13	There were a few things I noticed that could possibly be improved (but it's a prototype, so it's all good:)): – Especially in task 1, the text box could be less transparent.
		16	The underwater theme is inappropriate and the background is irritating and distracting.
		26	I felt a certain divergence between the look and content of the game. The interface looked like a child's game, while the content was that of an educational science major. This contrast makes it seem slightly inauthentic.
		31	It was a bit childish by my standards, but that's not a bad thing.
Technical problems	5	12	Unfortunately, the sound didn't work for me, so I couldn't do the relaxation exercise.
		17	The game hangs all the time, new levels just keep opening up.
		20	I actually liked everything. However, there are still one or two small technical problems. For example, in the section with the method of Loci, the turtle floated above the text in places.
		24	There was no music or sound (maybe it's caused by the web browser?).
		30	I had technical problems.
Text design	5	1	Information texts could be designed more clearly.
		3	Sometimes there is a lot of text in a confusing arrangement (in relation to the screen, e.g. font size).
		9	There was a lot of text and the knowledge to be learned was visually difficult to read with the blue background.
		11	There is a lot of info text in between, maybe highlight the most important points in color, especially if they are asked afterwards.
		16	Unnecessarily complicated sentences.
Instruction	3	4	It was often difficult to assess what to do, for example, to estimate the percentages in the pie chart.
		14	Some of the work instructions were not precise. For example, with the long-term, medium-term, and short-term goals, I didn't know whether I should define them or write down my own.
		25	Sometimes I would have liked to have received more precise instructions for some questions.
Feedback	3	18	The feedback function (somehow it doesn't seem fully developed to me – sometimes you can't tell if MC answers were correct and with the SMART acronym my entries were classified as incorrect even though they were correct).
		28	I would have liked to see the correct solution in more detail in the case of incorrect comments.
		29	The type of feedback, as I was missing an explanation for the wrong questions.
Progress indicator	3	10	You can't see exactly how far you've progressed in the game while you're playing.
		25	Sometimes I didn't know when to go to the next level.
		27	There was no level overview.
Navigation	2	27	You could not go back to levels you had already played.
		28	I didn't like the fact that you can't go back to read the solution after submitting it.
Task type	1	5	I did not like the right / wrong questions.

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