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Preface

The International Conference on Web-Based Learning (ICWL) has become the premier annual international conference on web-based learning. Organized by the Hong Kong Web Society, ICWL started in Hong Kong in 2002 and has so far been held in Africa (Cape Town), Asia (China, Malaysia, Hong Kong, Taiwan), Australia, and Europe (UK, Germany, Romania, Estonia, Italy).

In 2018, the 17th ICWL was held in Chiang Mai, Thailand. ICWL 2018 assembled five technical sessions covering the latest findings in various areas, such as: learning assessment and behavior, augmented reality, collaborative learning, game-based learning, learning content management, education case studies, and experience sharing. These papers were selected after a rigorous review process of 37 submissions from 21 countries. The review procedure included a double-blind review phase, with each paper receiving at least three reviews, followed by discussion between the Program Committee members and the program chairs. In all, 11 papers were selected as full papers, yielding an acceptance rate of 29%, in addition to four short papers.

Furthermore, the conference continued the new initiative, started by ICWL 2016, of holding the Third International Symposium on Emerging Technologies for Education (SETE) at the same location. SETE collected the traditional workshop activities managed by ICWL in the past years, and additionally featured a novel organization in tracks. Workshops and tracks added new and hot topics on technology-enhanced learning, providing a better overall conference experience to the ICWL attendees.

We thank all authors and participants who contributed to make this event a great success, the Technical Program Committee members and sub-reviewers who worked on the program, and the volunteers who handled much of the organization behind the scenes to make ICWL possible. We greatly appreciate the input of the ICWL Steering Committee representative whose help and advice was invaluable, and we would like to thank the Faculty of Science, Maejo University, for supporting this event and providing assistance with general arrangements.

August 2018

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Contents

Learning Assessment and Behavior

Q2A-I: A Support Platform for Computer Programming Education, Based on Automated Assessment and Peer Learning

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Abstract. Management and assessment of homework assignments in programming courses is a challenging topic both for researchers and practitioners. In the current paper we propose a solution based on the blending of automated evaluation and peer learning. More specifically, we introduce a platform called Q2A-I, which provides two main features: (1) automated management and assessment of homework submissions; and (2) peer interaction support on the programming tasks, by exchanging questions and answers through dedicated micro-forums. By (1) we try to relieve the teacher of the burden of manual evaluation of assignments, while still providing sufficient insight into the students' knowledge level to discover potential need for remedial interventions. By (2) we aim to capitalize on the benefits of peer learning, allowing students to request and provide help to each other, and rely on teacher support only in a limited number of cases. The paper provides a description of the Q2A-I platform, followed by an illustration of its practical use in the context of an introductory Computer Programming course. Results related to students' participation level as well as their subjective satisfaction with the platform are reported and discussed.

Keywords: Computer programming education · Homework
Automated assessment · Peer learning

1 Introduction

Computer Programming is one of the main disciplines the students get in contact with in Computer Science Education and it is present in both introductory and advanced learning activities and courses [1]. The main path for letting the learners acquire programming skills is in allowing for extensive programming training, with the undertaking of several programming tasks, accompanied by the related, timely

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provided feedback [2]. The accomplishment of such training activity takes often the form of homework [3].

The evaluation of homework can be a very rewarding activity for the teacher, as it can unveil misconceptions and may allow to plan acting on them, by means of remedial learning tasks. On the other hand, in a large class, this activity can be very demanding for the teacher, due to the high number of assignments to assess in a short time, in order to provide timely feedback. In this context, tools for automated evaluation of programming tasks can provide significant support in computer science education. Real time evaluation of homework programming assignments, with provision of feedback, is performed by means of static or dynamic analysis of programs (and sometimes by the integration of techniques from both methodologies). This approach has proven fruitful in increasing learners' programming proficiency [4–8].

At the same time, educational systems which provide support for social learning and peer interaction tend to increase students' participation and engagement [9]. In particular, platforms based on the exchange of questions and answers and student reputation have proven useful [10, 11]. This approach is suitable to the sociable, team-oriented nature of the current generation of students, who are open to sharing, seeking interaction, preferring peer-to-peer and group learning [12]. In addition, it answers students' expectations for immediate communication, instant responses, quick reactions (sometimes placing more value on speed than on accuracy), and prompt rewarding - as peer feedback is usually delivered much quicker than teacher feedback.

Furthermore, this approach can make less pervasive the teacher's intervention, with positive effects on the learner's self-guidance and self-esteem: sometimes the student might feel that a misconception, of which she is aware, could be solved just by means of interaction with peers (e.g., by exchange of questions and answers in a forum). This way the teacher could limit her intervention to possible moderation of the forum, while having time to focus on cases when her direct intervention is more needed.

In this paper we aim to merge the two approaches (automated homework assessment and peer learning), in the context of computer programming. More specifically, we propose a web-based educational platform called Q2A-I, which provides two main features: (i) automated management and assessment of homework submissions; and (ii) peer interaction support on the programming tasks, by exchanging questions and answers through dedicated micro-forums.

The rest of the paper is structured as follows: the next section includes an overview of related work. Section 3 provides a description of the Q2A-I platform, followed by an illustration of its practical use in the context of an introductory Computer Programming course in Sect. 4. Students' subjective learning experience with the platform is reported and discussed in Sect. 5. The paper ends with some conclusions and future research directions.

2 Related Work

Automated analysis, verification, and grading of programming tasks in education is a long standing research topic [13], especially ranging over applications to training in introductory programming, with the aim to support writing programs according to syntax and semantics of a given programming language, and to foster computational thinking and the development of problem solving skills [2, 14].

In the scope of this paper, a homework is a collection of programming tasks to be assessed. In general, programming tasks are analyzed to determine their correctness with respect to the problem at hand; other qualities of the programs are sometimes considered, such as the suitability of the implemented algorithm and the efficiency of the submitted code. In general, the program analysis is based either on Static Analysis (SA) - which gives feedback just by a syntactic and static-semantic examination, without actually running the program, or on Dynamic Analysis (DA) - which is basically done by executing the program, and measuring its success on significant test-cases.

SA approaches are addressed in [14, 15], where compiler generated errors are attached with explanations, in [16], where programs are evaluated based on the structural similarity with correct ones, and in [17], where detection of plagiarism is also managed.

In DA, the dynamic semantics of the program and its logic are considered, and the tests are designed to catch significant aspects of the expected behaviour of the program. In [6] a web-accessible system for programming task assessment is described, based on the application to programs of pre-determined sets of tests. Safety of the execution environment, plagiarism, and data privacy are also considered among the features of the system. Tools for competitive programming use the DA approach to manage well known programming contests [18, 19]. Kattis [4] proposes "programming exercises" aimed to offer both theoretical and practical learning experiences, in an environment providing automated testing; this is also used to support the programming competitions in ACM-ICPC finals. An evolution of the test-based approach managed through DA appears in systems where the students are called to devise the tests to be used for the program assessment. This approach has been shown fruitful in [7, 20]. A slightly different approach is described in [8], where the student proposes her own tests, and the program is assessed on them and also on a set of reference predefined tests. Finally, combining SA and DA is also possible, although not very frequent; [21] provides a noteworthy example.

Beside the automated assessment functionality, our Q2A-I system also provides a social learning space for the students, in which they can actively engage with each other. Indeed, "today, learning is at least as much about access to other people as it is about access to information" [22] and learning environments should be conducive to peer interactions, which trigger learning mechanisms [23]. In particular, providing opportunity for peer learning and peer tutoring is highly beneficial for the students, whether receiving or offering help [24]. Asking questions and providing answers to peers is a worthwhile learning activity, as understanding is socially constructed by means of conversations and interactions around specific problems [25, 26]. Thus, learning is seen as a product of participation in a community; online social settings and in particular question and answer support platforms foster this active participation and collaboration, engaging students and increasing interactions.

3 Q2A-I Platform Description

Q2A-I[1] is a web application built by adding a plugin into the Question2Answer system [27]. The plugin we implemented is aimed to support the administration of homework, with automated grading, and management of micro-forums based on question/answer interaction. The system is implemented in PHP on a Linux based server (*LAMP* architecture).

A Q2A-I homework, H, is a set of programming tasks $H = \{T_H^i, i \in [1, n_H]\}$. In the system, each homework has a dedicated area, showing its definition, and allowing to submit solutions for each one of the tasks. After submission, the student can see the related (automated) assessment. For a homework, and for the related tasks, the assessment consists of a sequence of tests. Tests for each task are predefined by the teacher, at homework definition time. This testing provides feedback on the homework tasks, based on a variety of aspects (*correctness*, i.e. success in the tests, *intricacy*, computed as the cyclomatic complexity, and *efficiency*, based on the average time of execution for the tasks, provided that all of them can run). The system features an anti-plagiarism tool, used to uncover and discourage cheating.

Beside the management of homework submission and assessment, Q2A-I provides the students with various means for social interaction and peer learning; in particular, the following functionalities are offered:

- Student s can propose a question Q^s related to a given task T_H^i (i-th task in the homework H);
- Student s can submit an answer A^s, for a question Q (proposed by any student, including s);
- Student s can comment on an answer A (proposed by any student, also s);
- Student s can comment on a comment proposed by any student $s' \neq s$;
- Student s can mark (*upvote*) a question $Q^{s'}$ (with $s' \neq s$);
- Student s can mark (*upvote*) an answer $A^{s'}$ (with $s' \neq s$);
- Student s, who proposed question Q, can select an answer, A, among all the answers submitted to Q, and declare it to be the best answer for Q.

Associated to the above listed social interactions, is a concept of reputation for a given student s: *rep(s)*. As each interaction produces a value (*interaction points - IPs*), *rep(s)* is computed as the sum of all the *IPs* associated to s's interactions.

More specifically, interaction points are gathered by means of active participation:

- Asking questions, answering to questions, commenting (*participation by content creation*)
- Upvoting questions, upvoting answers, selecting the best answer for a question (*participation to content quality selection*)
- A student receives other *IPs* based on votes obtained by her questions or answers, and based on having her answers selected as the best for a question (*usefulness to others*).

[1] Q2A-I platform (*Q2A-Informatica*), available at: https://Q2A.di.uniroma1.it.

Overall, Q2A-I entails two very important features for computer programming instruction. The first feature is that the automated dynamic assessment of programming tasks provides the student with meaningful and real-time feedback about her solution. This may allow the student to learn from errors and, over time, to be able to produce more correct solutions.

The second feature of Q2A-I is the possibility to support and measure the social interaction of a learner in the online environment. Such interactions happen in dedicated micro-forums, each one related to a specific homework task. The contributions coming from the students in these forums are focused on the definition of questions, answers to such questions, upvoting (declaring the usefulness of a question, or the agreement on an answer), and commenting. The significance of this targeted learning community is twofold. On one hand, the students are helped to stay focused on individual homework topics. On the other hand, the amount of interaction in a given forum, represented by the number of questions, the number of answers, the quality of such answers, and the frequency of upvoting, can help the teacher assess the educational value of a homework, or reveal its inadequacy to its aim.

4 Using Q2A-I in Practice

The Q2A-I system was used in a course on *Basics of Computer Programming (with Python)*, for Bachelor Program in Computer Science, Sapienza University of Rome, fall semester 2017–2018.

Students had 5 homework assignments proposed by the system. The final grade (a value between 18 – lowest, and 30 – highest) would be the average grade of the submitted assignments; so a student had to submit at least 3 fully successful homework assignments to reach at least the minimum grade, otherwise the student would fail. For a homework, H, the evaluation is the average of the (usually three) associated tasks, T_H^i, whereas a task's assessment is as follows:

- 0–30 points according to the average percentage of successful tests for that task
- 0–2 points according to the output of the cyclomatic complexity computation (intricacy of the code: the less, the better)
- 0–2 points for the efficiency of the proposed solutions (measured as the average execution time during the tests, only if all the tests are successful).

As mentioned in the previous section, an anti-plagiarism mechanism is in place in Q2A-I, to discourage cheating behaviors. In particular, during our trial we applied the following rules: given a solution for homework $H = \{T_H^i, i \in [1, n_H]\}$, submitted by student s, a textual anti-plagiarism analysis is performed on each task solution T_H^i:

- if an act of substantial cheating is unveiled, and this is the first time for s that such an event occurs, then a *yellow card* is presented to s;
- if cheating is unveiled for a student s who already has a *yellow card*, then a *red card* is issued for s.

The student who has been “red-carded” on homework *H*, has *H* canceled, and will have to perform a special examination, in presence, invigilated, consisting basically in producing a homework similar to *H*.

Our study was conducted in a class comprising of 432 students; 112 of them did not register with Q2A-I and did not submit any homework, dropping out of the course. Out of the remaining 320 students, only 111 had a level of participation characterized by more than 500 *IPs*, which we considered to be the threshold for a fair engagement. Figure 1 shows a comparison between the level of participation in Q2A-I and the final grade obtained for the homework assignments; a general correspondence between higher participation and better grades can be observed. A total of 183 students failed, corresponding to a very low average degree of participation in Q2A-I.

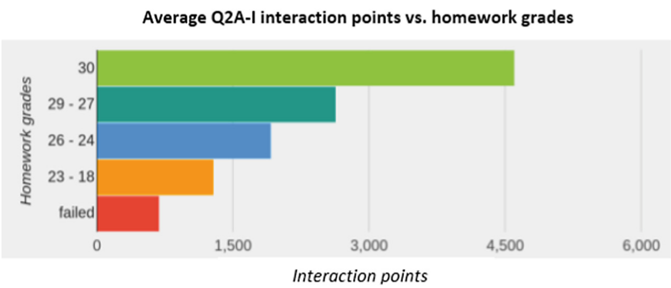

Fig. 1. Relation between students’ participation in Q2A-I and homework grades; each bar represents the average *IPs* value obtained by the students in the corresponding grade bracket.

In our study, interaction points were granted according to the following criteria:

– 100 *IPs* were granted for registering in Q2A-I;
– for Questions: posting = 20 *IPs*; having_it_upvoted = 10 *IPs*; voting = 10 *IPs*;
– for Answers: posting = 40 *IPs*; having_it_upvoted = 20 *IPs*; voting = 10 *IPs*;
– selecting an answer as the best for one’s own question = 30 *IPs*;
– having one’s own answer selected as best for a question = 300 *IPs*;
– posting comments was not eligible for *IPs*.

The Q2A-I system embeds some facilities supporting data visualization. In particular, it produces a resource in GEXF format (Graph Exchange XML Format), which can be used for automated or manual visual representation and help analysis by the teacher. Figure 2 shows a visualization of the social network built by the students in Q2A-I, while interacting and gaining *IPs*. The figure was obtained by feeding the data in Gephi [28, 29] and selecting only the students that accumulated at least 500 *IPs* (i.e., 111 students). HITS (Hyperlink-Induced Topic Search) algorithm was used, which is aimed to evaluate the rank of nodes, according to incoming links (*Authority*) and referenced ones (*Hub*). For the visualization of students’ interaction in the Q2A-I social network, the interpretation of the rank elements is as follows:

– Authority: basically this rate shows the usefulness of the student's contributions (as they elicited further participation, and content production, from the others). Intuitively, this is based on the points derived by the votes obtained by the questions and answers posted by the student, and by the amount of answers obtained by the student's questions.
– Hub: this rate shows how the student participated in the network, by adding contents or votes in relation to contributions of others (answers posted by the student, and student's voting activity, on questions/answers of others).

Overall, we can see that there is a relatively small number of students with very active participation in Q2A-I, who drive most learner interactions. While having both posters and lurkers in the learning community is expected, our goal as instructors is to try to increase students' engagement with Q2A-I; a more active and even contribution to the community is highly desirable.

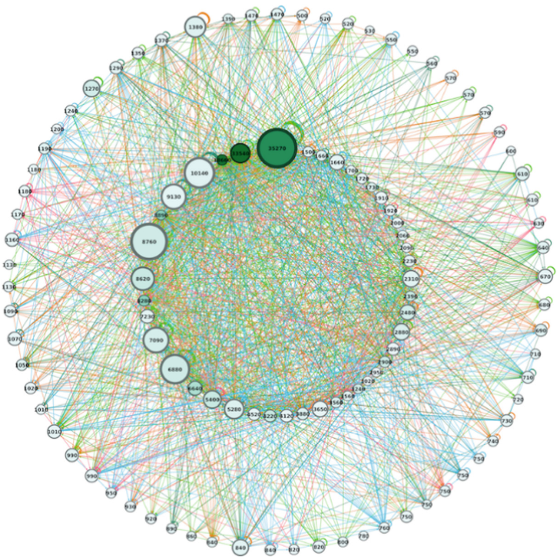

Fig. 2. Visual representation of the Q2A-I social learning network. Each node represents a student; each edge represents one interaction between the students, whereas the edge color depends on the homework related to the interaction. Node dimension indicates how high the authority rate is, while node color indicates the hub rate (the darker the color, the higher the rate). (Color figure online)

5 Students' Experience with Q2A-I

Beside the objective measures of system use, presented in the previous section, students' subjective satisfaction with the platform is an important success indicator. Therefore, at the end of the semester, we asked students to fill in an opinion survey in order to gauge their learning experience with Q2A-I. The questionnaire addressed the following issues: (1) a general evaluation of the course and its lectures; (2) the perceived difficulty of the homework assignments; (3) an evaluation of Q2A-I's usefulness; (4) suggestions for improvements. A total of 132 students filled in the questionnaire and a summary of their answers is reported next.

According to Fig. 3, the answers provided in Q2A-I were considered generally helpful for the comprehension of course topics; in particular, the high appreciation for peers' answers is relevant.

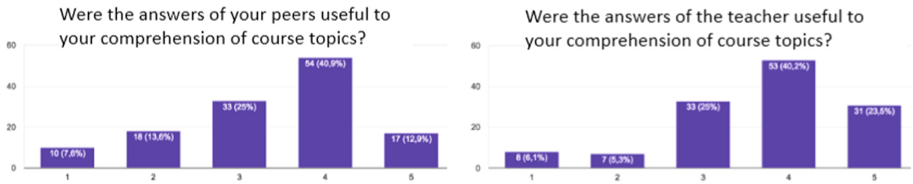

Fig. 3. Students' perceived usefulness of the answers provided in Q2A-I; a 5-point Likert scale was used (1 - Not at all useful; 5 - Very useful). Considering values 3 to 5 as positive, there is a large appreciation by the respondents: 78.8% for the peers' answers and 88.7% for teachers' answers.

As far as the level of participation in Q2A-I is concerned, Fig. 4 suggests a relatively low involvement reported by the students.

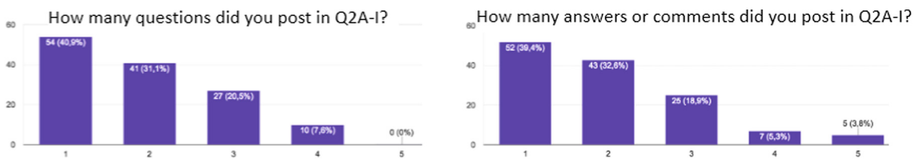

Fig. 4. Students' perceived participation level in Q2A-I, on a 5-point Likert scale (1 - Very few; 5 - Very many); considering values 1 and 2 as a substandard assessment of one's own participation in terms of questions, answers and comments, about 72% of the respondents provide such a negative evaluation.

Regarding the effectiveness of Q2A-I, as perceived by the students, Fig. 5 shows that the overall participation in the system was considered helpful in gaining programming competence.

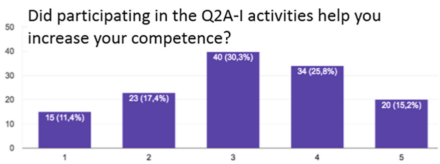

Fig. 5. Students' perceived effectiveness of Q2A-I, on a 5-point Likert scale (1 - Very little; 5 - Very much); 71.2% of the respondents considered their participation helpful at least in a moderate degree.

Finally, the number of homework assignments submitted for evaluation is a relevant measure for student success. Figure 6 shows that 61.4% of the respondents submitted at least 4 assignments and 71.2% at least 3 assignments. This is a relatively good result, given that the minimum number of assignments to be submitted for having a reasonable chance of passing the course is 3.

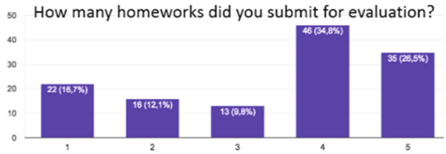

Fig. 6. Number of homework assignments submitted by the students

6 Conclusion

We designed and implemented a platform for the management and assessment of homework assignments in computer programming courses, called Q2A-I. In addition to the automated assessment of programming tasks, the system provides peer learning support, by exchanging questions and answers through dedicated micro-forums. The platform has been successfully used in practice, in the context of an introductory Computer Programming course. Results showed that students with a high level of participation in Q2A-I also obtained the highest grades. Furthermore, students were mostly satisfied with the system: they perceived the answers provided in Q2A-I as generally useful for the comprehension of course topics and the platform was considered helpful in gaining programming competence.

Nevertheless, the number of students with active participation in Q2A-I was not very high, so our goal is to increase students' engagement with the platform; implementing mechanisms for driving a more active and even contribution to the learning community is one of our future work directions. Furthermore, we plan to perform more in-depth analyses regarding students' interactions (including their evolution over time), as well as the impact of Q2A-I system on the learning process.

References

1. Computer Science Curricula 2013 Final Report. The Joint Task Force on Computing Curricula, ACM/IEEE-Computer Society (2013)
2. Pieterse, V.: Automated assessment of programming assignments. In: Proceedings CSERC 2013, pp. 45–56 (2013)
3. Pozenel, M., Furst, L., Mahnic, V.: Introduction of the automated assessment of homework assignments in a university-level programming course. In: MIPRO 2015, pp. 761–766 (2015)
4. Enstrom, E., Kreitz, G., Niemela, F., Soderman, P., Kann, V.: Five years with kattis – using an automated assessment system in teaching. In: Proceedings of FIE 2011 (2011)

5. Brusilovsky, P., Sosnovsky, S.: Individualized exercises for self-assessment of programming knowledge: an evaluation of QuizPACK. J. Educ. Res. Comput. **5**(3), 91–111 (2005)
6. Joy, M., Griffiths, N., Boyatt, R.: The BOSS online submission and assessment system. J. Educ. Res. Comput. **5**(3), 4–31 (2005)
7. Edwards, S.H., Perez-Quinones, M.A.: Web-CAT: automatically grading programming assignments. In: Proceedings of ITiCSE 2008, pp. 328–328 (2008)
8. de Souza, D.M., Maldonado, J.C., Barbosa, E.F.: ProgTest: an environment for the submission and evaluation of programming assignments. In: Proceedings of CSEE&T 2011 (2011)
9. Vassileva, J.: Toward social learning environments. IEEE Trans. Learn. Technol. **1**(4), 199–214 (2008)
10. Sterbini, A., Temperini, M.: Collaborative projects and self evaluation within a social reputation-based exercise-sharing system. In: Proceedings of WI/IAT 2009 (SPeL Workshop), pp. 243–246 (2009)
11. Sterbini, A., Temperini, M.: SocialX: an improved reputation based support to social collaborative learning through exercise sharing and project teamwork. In: Information Systems and Modern Society: Social Change and Global Development, pp. 66–85 (2013)
12. Redecker, C.: Review of learning 2.0 practices: study on the impact of web 2.0 innovations on education and training in Europe. In: JRC-IPTS (2009)
13. Hollingsworth, J.: Automatic graders for programming classes. Commun. ACM **3**(10), 528–529 (1960)
14. Hristova, M., Misra, A., Rutter, M., Mercuri, R.: Identifying and correcting Java programming errors for introductory computer science students. In: Proceedings of SIGCSE 2003, pp. 153–156 (2003)
15. Watson, C., Li, F.W.B., Godwin, J.L.: BlueFix: using crowd-sourced feedback to support programming students in error diagnosis and repair. In: Popescu, E., Li, Q., Klamma, R., Leung, H., Specht, M. (eds.) ICWL 2012. LNCS, vol. 7558, pp. 228–239. Springer, Heidelberg (2012). https://doi.org/10.1007/978-3-642-33642-3_25
16. Naudé, K., Greyling, J., Vogts, D.: Marking student programs using graph similarity. Comput. Educ. **54**(2), 545–561 (2010)
17. Rahman, K.A., Nordin, M.J.: A review on the static analysis approach in the automated programming assessment systems. In: Proc. ICSECS'07 (2007)
18. Dagienė, V.: Sustaining informatics education by contests. In: Hromkovič, J., Královič, R., Vahrenhold, J. (eds.) ISSEP 2010. LNCS, vol. 5941, pp. 1–12. Springer, Heidelberg (2010). https://doi.org/10.1007/978-3-642-11376-5_1
19. Combéfis, S., Wautelet, J.: Programming trainings and informatics teaching through online contests. Olymp. Inform. **8**, 21–34 (2014)
20. Edwards, S.H.: Improving student performance by evaluating how well students test their own programs. J. Educ. Res. Comput. **3**(3), 1 (2003)
21. Wang, T., Su, X., Ma, P., Wang, Y., Wang, K.: Ability-training-oriented automated assessment in introductory programming course. Comput. Educ. **56**(1), 220–226 (2011)
22. Scholz, R.T.: Introduction: learning through digital media. In: Learning Through Digital Media. Experiments in Technology and Pedagogy. The Institute for Distributed Creativity (2011)
23. Dillenbourg, P.: What do you mean by collaborative learning?. In: Collaborative Learning: Cognitive and Computational Approaches, pp. 1–19. Elsevier, New York City (1999)
24. Topping, K.J.: Trends in peer learning. Educ. Psychol.: Int. J. Exp. Educ. Psychol. **25**(6), 631–645 (2005)
25. Ala-Mutka, K.: Review of learning in ICT-enabled networks and communities. JRC-IPTS (2009). http://ipts.jrc.ec.europa.eu/publications/pub.cfm?id=2721

26. Srba, I., Bieliková. M.: Askalot: community question answering as a means for knowledge sharing in an educational organization. In: Proceedings of CSCW 2015 Companion, pp. 179–182 (2015)
27. Question2Answer homepage. http://question2answer.org/. Accessed 15 Apr 2018
28. The Open Graph Viz Platform. https://gephi.org/. Accessed 15 Apr 2018
29. Bastian, M., Heymann, S., Jacomy, M.: Gephi: an open source software for exploring and manipulating networks. In: Proceedings of ICWSM 2009, pp. 361–362 (2009)

A Badge for Reducing Open Answers in Peer Assessment

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Abstract. We present a novel approach to peer assessment of a team-based project exploiting badges that represent individual contributions to the task and teamwork related traits. We show that this approach has positive influence on engagement in peer assessment compared to free-text open questions. We also focus on the question if feedback obtained in this way is informative and to which extent it can serve as replacement for open free-text questions.

Keywords: Badges · Peer assessment · Teamwork

1 Introduction

Team-based projects employed as educational activities have several benefits for students: development of interpersonal skills, communication skills, pondering other points of view, ability to more effectively develop a complex project, insight into group dynamics, etc. [5,7,14]. Working in teams represents also an interesting and effective way of learning [3] that improve student engagement, performance and often also their marks [7]. However, for the teacher it is difficult to assess the individual's contribution to the group project. Grading all group members with the same mark or number of points is usually perceived as unfair. It can result in a variety of problems such as a sizable decrease in effort of particular students, freeloading, etc. [1,6].

There are various methods for reducing problems of this kind. Among others, peer assessment, or involving students in the assessment process in some way can be helpful. Such methods can be implemented in several diverse ways [7].

In our course we introduced peer assessment of teamwork already three years ago [10,11]. The performance of particular team members was assessed using percentual evaluation of each other's contribution, in compliance with so called Fink method [15]. We have employed also verbal justification in form of open textual questions to supplement the percentage rating. This secondary assessment is essential, because it provides formative feedback between the team members and a source of validation of the primary numerical rating. Students expressed their satisfaction with peer assessment of teamwork, however, they were not enthusiastic about writing the verbal evaluation.

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To deal with this problem we experimented with employing gamification in the peer evaluation process. Open textual questions were replaced by the possibility to award badges between team members. We hypothesized that students will be much more willing to provide the feedback in form of badges. In addition, we wanted to verify if the badges were somehow representative with respect to the students' individual contribution within a team, and if this form of peer assessment was useful to the instructors. In this paper we present our preliminary study which we conducted in one course run. The results are encouraging and we would like to explore this direction in the future.

2 Experiment

2.1 Course and Assignment

The experiments described in this paper were conducted during the latest run of a Master's level course concerned with web design methodology and user experience. The course is part of an Applied Informatics curriculum. As one of the main educational activities, it features a whole-semester practical project during which students design and develop web application of their own choice.

The assignment is team-based; students self-form 3–4 member teams. It is split into four consecutive rounds: (1) specification, (2) prototype development and testing, (3) application development, (4) content development.

During each round the students work in their team, then they conduct peer review of other teams' submissions, and consecutively they are able to take the feedback into the account and finalize the submission for grading.

It is one of our goals to make the assignment similar to real web application development process. Therefore we allow the students to split the responsibilities in their teams arbitrarily, based on their own agreement.

To be able to asses the individual contributions of the team members, we have introduced teamwork reviews [10,11]. We rely on the Fink method [15] wherein each team member splits 100 points among the remaining $n-1$ members of an n-member team. If the points are split equally, this means that in the evaluator's point of view all other team members contributed by the same amount of work. If the evaluator deems that someone contributed more than the others, she may adjust the points accordingly. No one evaluates herself. In the end, the points received by each member from all her colleagues are summed up. In the even case, everyone receives 100 points, hence the points may be viewed as per cent scales.

The evaluation of the project, which takes into the account both the instructors' assessment of the submissions but as well the team review scores, is the main part of the course grading. Therefore it is important to assure that the team reviews are fair, and to have some additional justification to supplement the mere numeric evaluation respective to the Fink method as described above.

In the previous years we relied on textual input from the students. Besides for awarding the points, all students were asked additional open questions regarding each other team member. We have used the following three questions:

1. *Contribution summary:* Evaluate your colleague's contribution in this round of the project. Summarize what this person has done, and if you are satisfied by his or her contribution.
2. *Most valuable thing:* What is the single most valuable thing this person has done for your team?
3. *What can be improved:* What is the single most important thing this person could do to more effectively help your team?

While the outputs that we received from these open questions were useful (if provided), the task of filling out three questions per team member was viewed as laborious by many students and they were reluctant to fill in the answers properly. We resorted to awarding students a small number of evaluation points just for filling-in all the review forms, which worked to some extent, but was not ideal.

2.2 Badges

In the last course run, we have looked for ways how to improve the team review process by reducing the effort needed by the students and perhaps making this activity less boring and more fun; while still assuring some form of independent supplementary feedback besides for the split of points. As we explain in this section, we have resorted to allow students to evaluate their team members' contribution by awarding badges.

The teamwork review forms were modified as follows: (1) The split of points between all team members (based on the Fink method) – this part remained unchanged; (2) We added a new part in which students were able to award badges to each team member; (3) We kept one open textual field for any additional feedback to each team member, but it was optional.

The remaining parts of the project assignment were not changed, although the project was split into 4 rounds instead of 3 compared to the previous years.

Since the badges were to be used to supplement the evaluation of team members' individual contribution during each round, we have put together a set of 15 badges covering teamwork related skills and other skills needed to fulfil the task. The complete set of badges is showed in Fig. 1.

The set of badges was the same during all four rounds. Therefore it was possible to be awarded each badge multiple times during each round but also again during next rounds. For this reason the badges were aggregated into four levels of each badge: regular (green), bronze, silver, and gold. If a student earned a particular badge in one round, the badge was shown as regular. Badges earned in two rounds were shown as bronze, silver for three rounds, and finally golden for earning the badge in four rounds. The number of distinct students who awarded the badge did not matter.

3 Findings

During the last course run we have conducted an experiment, during which we have introduced badges in teamwork reviews, as described above. There were 17

Fig. 1. Set of badges; badge levels represented by different color (Color figure online)

students taking the course, which formed five 3–4 member teams. The aim of the experiment was to answer to the following research questions:

1. Did students use and did they like to use badges?
2. Were badges representative w.r.t. the students' contribution to the teamwork?
3. Were badges useful to the instructors?

The research questions were addressed by the following methods: (1) We collected and evaluated the data about the usage of badges. (2) In the end of the course we surveyed students about their opinions, the survey was anonymous and voluntary. It focused on the student's perception of the task and its information value, and utility. All 14 students who passed the exam participated in the survey. (3) We have also conducted an interview with the three instructors of the course, especially in connection to the third research question.

We have performed a qualitative analysis of the collected data. The findings are presented in this section.

3.1 Did Students Prefer Badges to Written Feedback?

Since we implemented badges as a reaction to students' complaints about written team-reviews, the foremost interest of our research was to find out if the students enjoyed this kind of evaluation and to what extent they used badges. Thus we analysed the collected data and also asked several related questions in the survey.

We found that each student awarded a badge 24–96 times. The number of times a student earned a badge was 4–100. See Fig. 2 for details. This translated into 225 aggregated badges: 39 regular, 42 bronze, 51 silver, and 93 gold. Helpful, Team Player, and Communicative were the most popular, while Motivator, Neat Coder, and Hacker were used the least.

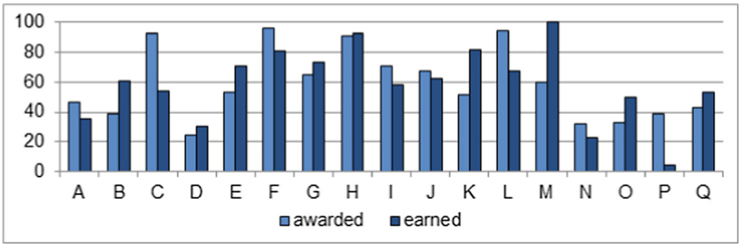

Fig. 2. Badges awarded and earned per person (no. of times); A–Q stand for individual students

The first multiple-choice question in the survey targeted students' overall opinion on the whole team review system with the list of answers as follows: It was fair, I was satisfied; It helped us split project points fairly; It helped us improve teamwork; I did not consider it fair; It did not help improve anything; Other. Students were allowed to tick all the choices that were relevant. After sorting the "other" answers, we found that we obtained 20 positive, 2 neutral and 2 negative answers (see Fig. 3).

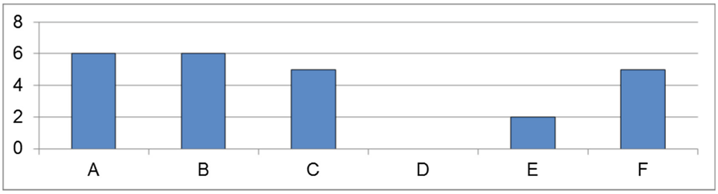

Fig. 3. What is your overall opinion of our team-review system? A – It was fair, I was satisfied; B – It helped us split project points fairly; C – It helped us improve teamwork; D – I did not consider it fair; E – It did not help improve anything; F – Other

In the following two questions we investigated if students liked to earn badges (Q2) and if they liked to assess their colleagues with badges (Q3). The answers were on the scale from 1 (the most negative option) to 5 (the most positive option). As shown in Fig. 4(a) both questions were answered mostly positively or neutrally.

Students were also asked to justify their answers to these two questions. Two students who answered Q2 negatively saw badges as not entirely objective and useless because of not having any impact on the final grade. Positive answers emphasized good feelings associated with earning an achievement, and getting feedback from peers. Students also appreciated that assessing with badges is fast and accurate, some of them considered badges to be cool and interesting.

We asked students if they would rather assess their colleagues by written comments (Q4 in Fig. 4(b)). Only 12 students answered, all of them preferred badges to verbal comments since they regard them as fast, easy to use and accurate.

The question if students would like to use badges in other courses was again answered mostly positively (Q5 in Fig. 4(b)). However, 2 neutral and 4 negative answers also occurred.

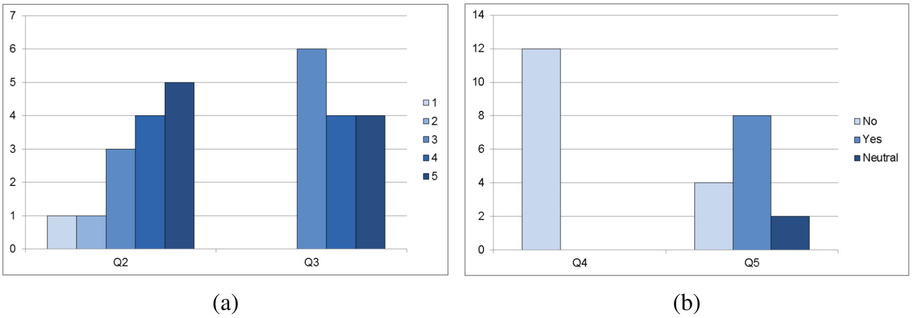

Fig. 4. (a) Q2: Did you like to earn badges? (Scale 1–5: I strongly disagree – I totally agree); Q3: Did you like to assess your colleagues with badges? (Scale 1–5: I did not like it at all – I really enjoyed it); (b) Q4: Would you rather assess your colleagues by written comments than by badges?; Q5: Would you like to use badges in other courses?

Based on the survey outcomes we can conclude that students used badges and liked to use badges. This finding was also confirmed by the teachers in the interview. Although rewarding teammates with badges was an optional part of team review, teachers were pleased with the amount of badges students awarded to each other.

From the data, it is evident that there were only 5 instances of a student assessing one of her peers in the particular round with no badge. However, we found out that this way they expressed their discontent with the teammate's contribution. In another significant case, when a team decided to always assess all team members in an egalitarian way, the team leader used the badges and verbal comments to distinguish hard-working teammates from those who have not contributed much to the teamwork. We observe that the badges provided some additional useful tool for this student to express feedback without affecting his colleague's score. Thus badges provided more flexibility in this case.

3.2 Can Badges Reflect Students' Contribution?

In the research question 2 we were concerned with whether the badges awarded to a student reflect her contribution within the team, at least to a certain extent.

To evaluate this question, we have included four additional questions (Q6–Q9) in the survey in which we asked whether the students can match the awarded badges to their perception of the actual contribution of each team member. The students answered on the scale from 1 (I strongly disagree) to 5 (I totally agree). The results are shown in the Fig. 5.

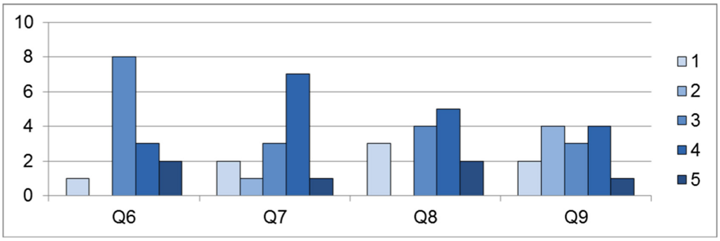

Fig. 5. Q6: Do you think that the badges you got during team review represent your teamwork well? Q7: Do you think that the badges your teammates received represent the work they did on the project? Q8: Did the badges help you realize your strengths within teamwork? Q9: Did the badges help you realize what you need to improve within teamwork?

Looking at Q6 and Q7, we observe that the vast majority of students were either neutral, or positive regarding this issue; much more positive when it comes to their perception of their teammates' badges than to their own. Looking at Q8 and Q9 we may conclude that the majority of students saw that badges reflected their strengths, while much smaller share of students thought that they reflected their weaknesses. This is probably caused by the fact that there was no badge in our badge set that could be used to describe negative behaviour, only the lack of awarded badges could be seen as a form of such feedback.

Looking at the same problem from the instructors point of view we obtain the research question 3. The instructors, however, had a more limited perception of students' split of responsibilities and their individual contributions. This perception is derived from their overseeing of the practical sessions during which part of the students' work was carried out. Therefore the research question is also more loosely formulated: we wanted to find out, if the badges are useful to the teachers, especially in order to understand who of the team members have contributed more and who have contributed less to the project.

We learned that especially the number of received badges could be seen as an indicative. The instructors noticed certain correlation between student engagement in the project, the split of points earned from their teammates, and the number of badges they have earned. This correlation was also observable in time: a person who worked more in the beginning earned more badges then, while later on she earned less badges because she worked less.

In a few notable cases, they were able to match some of the students' badges with their perceived traits/contribution within the project. This was especially true with the badges such as “leader”, “creative”, or “communicative”. But most of the badges were intended to be earned for a behaviour which was not always possible to observe by the instructors in the given timespan of practical sessions.

All in all the instructors concluded that the badges were useful to some extent. Textual answers would be more indicative, if only students have not been reluctant to provide them.

3.3 Other Findings

Our survey included also an open question regarding other badges that might be useful. We have received several suggestions for some kind of negative badge, that could be awarded to teammates who did not contribute sufficiently.

Independently, this issue was brought by the instructors during the interview. There was no clear consensus apart from that there were situations in which such a badge could be useful. However, two out of the three instructors expressed concerns that it could also be misused by the students. Still, they would be curious to try it at least as an experiment. When asked how should such a badge could be named, “Participation Trophy” came out as a possible candidate.

From the other questions asked in the survey, we found out that 13 students considered the combination of a picture and a caption sufficient to explain the meaning of each badge, only one student would welcome a more detailed explanation. Also, most students – 9 out of 14 – considered the experience of peer-reviewing rather useful with regard to their future job.

4 Related Work

Along with an explosion of group-based activities in education [7] a problem of assessment of individual contributions to the group work arose. There are various approaches how to deal with this problem [7,12], among others, active involvement of students in the assessment process is being explored.

The ability to evaluate the contribution of the others to a teamwork is considered one of the key skills required in IT area [18]. However, the responsibility to allocate individual scores to all teammates according to their individual contributions was shown to be too difficult for students who were not trained for such a task and resulted in egalitarian evaluation [12]. Fortunately, peer assessment is becoming a widespread educational activity that helps students to develop the evaluation, feedback and review skills already during their studies [18].

The peer assessment procedure is usually based on one of the two approaches [12]: the holistic one (rating teammates by a single grade) and the category-based one (rating several predefined criteria). As shown by Lejk and Wyvill [12] the holistic method is more in line with the aim of group assessment than the category specific approach. Moreover, it is even more positively accepted by students [13].

Peer assessment can be carried out either in summative or in formative way [4,17]. The latter one allows for formative feedback that can help students to focus on their learning and enhance the learning experience.

Brooks and Ammons [2] observed that peer assessment may have a role in forming the students' attitude towards their work. They pointed out the significance of an early and multiple points feedback during the group project development to the improvement of team members' contributions and reduction of freeloading.

Aiming to encourage and moderate the students' collaboration and to engage them in the assessment process, various gamification-based approaches were suggested. Some of them use badges – digital pictures with meta-data. Although digital badges originated in digital games, technologies for awarding digital badges outside of the game context were developed and badges started to be used as a motivation factor in a broader context, such as in internet banking, or in various mobile and web applications for different activities [21]. Digital badges are used in education for a few reasons – they might be used as a motivation, as a recognition of status, clear, evidence-based credentials, a visual evidence of achievement easily communicated and understood by observers and as a guide or a signpost communicating relevant targets to learner [8,19].

Moccozet et al. [16] introduced a framework for group work evaluation enhanced by gamification components – user points and scores. As the authors conclude, this learning platform not only encourages students to contribute and cooperate, but also covers the "free rider" problem as it provides the teacher with information about the student's individual contribution.

Hamari [9] reported results of a field experiment conducted in a real existing service gamified through badges. According to the findings of this study participants who actively monitored their badges and badges of the others were showing significantly higher activity.

Tenório et al. [22] proposed a gamified peer assessment model to deal with the lack of student engagement and motivation. Several gamification elements, such as points, rankings, badges, medals, and missions, were used. According to the authors' findings, gamification motivated students to participate in activities within this platform.

Badges as gamification elements were also used for summative peer assessment in a project-based learning scenario [20]. During the presentations of team projects other students were asked to reward their colleagues with badges according to the quality of their project.

Nevertheless, all of these studies used the gamification elements in peer evaluation of the others' work. In our research, badges were used for peer assessment of teammates' contribution and attitude.

5 Conclusions

We report on a new gamified approach to peer assessment of individual contributions to a team-based project. We have replaced free-text open questions, which the students were reluctant to answer in the past, with a set of badges representing traits relevant to the project and to the teamwork.

Based on the results of our preliminary research presented in this paper, we can conclude that (a) students were much more active in awarding badges when compared to the past experience with open questions; (b) to a limited extent, students were able to recognize the utility of the badges as a form of formative feedback, an aspect that we would like to reinforce in the future; and (c) to a slightly higher extent the badges served to the instructors as a form of validation of the primary numeric ratings assigned during the peer assessment. We also report on other findings, especially on the possible introduction of badges representing negative traits.

These results encourage us to continue in this direction in the future, when we would like to especially focus on further increasing the amount of feedback delivered via the badges to the students, but to the instructors as well.

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References

1. Bacon, D.R., Stewart, K.A., Silver, W.S.: Lessons from the best and worst student team experiences: how a teacher can make the difference. J. Manag. Educ. **23**(5), 467–488 (1999)
2. Brooks, C.M., Ammons, J.L.: Free riding in group projects and the effects of timing, frequency. J. Educ. Bus. **78**, 5 (2003)
3. Conway, R., Kember, D., Sivan, A., Wu, M.: Peer assessment of an individual's contribution to a group project. Assess. Eval. High. Educ. **18**(1), 45–56 (1993)
4. Deeley, S.J.: Summative co-assessment: a deep learning approach to enhancing employability skills and attributes. Act. Learn. High. Educ. **15**(1), 39–51 (2014)
5. Gatfield, T.: Examining student satisfaction with group projects and peer assessment. Assess. Eval. High. Educ. **24**(4), 365–377 (1999)
6. George, J.M.: Extrinsic and intrinsic origins of perceived social loafing in organizations. Acad. Manag. J. **35**(1), 191–202 (1992)
7. Gibbs, G.: The assessment of group work: lessons from the literature. Assessment Standards Knowledge Exchange, pp. 1–17 (2009)
8. Gibson, D., Ostashewski, N., Flintoff, K., Grant, S., Knight, E.: Digital badges in education. Educ. Inf. Technol. **20**(2), 403–410 (2015)
9. Hamari, J.: Transforming homo economicus into homo ludens: a field experiment on gamification in a utilitarian peer-to-peer trading service. Electron. Commer. Res. Appl. **12**(4), 236–245 (2013)
10. Homola, M., Kubincová, Z., Kľuka, J., Švolík, M., Darjanin, M., Zapalač, P.: Team workflow and peer review in a virtual learning environment. In: 2017 16th International Conference on Information Technology Based Higher Education and Training, pp. 1–6. IEEE (2017)
11. Kubincová, Z., Homola, M., Dropčová, V.: Peer reviews in a web design course: now students like them too. In: Wu, T.-T., Gennari, R., Huang, Y.-M., Xie, H., Cao, Y. (eds.) SETE 2016. LNCS, vol. 10108, pp. 624–634. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-52836-6_66
12. Lejk, M., Wyvill, M.: Peer assessment of contributions to a group project: a comparison of holistic and category-based approaches. Assess. Eval. High. Educ. **26**(1), 61–72 (2001)

13. Lejk, M., Wyvill, M.: Peer assessment of contributions to a group project: student attitudes to holistic and category-based approaches. Assess. Eval. High. Educ. **27**(6), 569–577 (2002)
14. Mello, J.A.: Improving individual member accountability in small work group settings. J. Manag. Educ. **17**(2), 253–259 (1993)
15. Michaelsen, L.K., Fink, L.D.: Calculating peer evaluation scores. In: Team-Based Learning: A Transformative Use of Small Groups in College Teaching, pp. 241–248. Stylus, Sterling (2004)
16. Moccozet, L., Tardy, C., Opprecht, W., Léonard, M.: Gamification-based assessment of group work. In: 2013 International Conference on Interactive Collaborative Learning (ICL), 171–179. IEEE (2013)
17. Orsmond, P., Merry, S., Callaghan, A.: Implementation of a formative assessment model incorporating peer and self-assessment. Innov. Educ. Teach. Int. **41**(3), 273–290 (2004)
18. Raban, R., Litchfield, A.: Peer assessment in large group projects: forming professional attitudes in IT students. In: Australian Conference on Science and Mathematics Education (2012)
19. Rughiniş, R., Matei, S.: Digital badges: signposts and claims of achievement. In: Stephanidis, C. (ed.) HCI 2013. CCIS, vol. 374, pp. 84–88. Springer, Heidelberg (2013). https://doi.org/10.1007/978-3-642-39476-8_18
20. Šuníková, D., Kubincová, Z., Simionescu, S., Popescu, E.: Peer assessment augmented with digital badges: a first experience report. In: 2017 16th International Conference on Information Technology Based Higher Education and Training, pp. 1–5. IEEE (2017)
21. Šuníková, D., Kubincová, Z., Navrátil, M.: How to use open badges? In: Information and Communication Technology in Education, pp. 222–230 (2015)
22. Tenório, T., Bittencourt, I.I., Isotani, S., Pedro, A., Ospina, P.: A gamified peer assessment model for on-line learning environments in a competitive context. Comput. Hum. Behav. **64**, 247–263 (2016)

Leverage the Learning Behaviour of Students in Online Courses with Personalised Interventions

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Abstract. Feedback is a vital element for effective learning as it helps students to understand the subject being studied and give them clear instructions on how to improve their learning. It has also been stated that feedback is strongly related to student achievement and improve the self-awareness, enthusiasm and motivation of students for learning. As a result, it is a challenging problem for modern online learning systems to provide suitable feedback to students that is tailored to their learning needs and support different aspects of their learning. In particular, in this paper we describe how we have used personalised feedback and interventions, that are automatically triggered by the learning environment at different course phases, in order to leverage the learning behaviour of students and draw their attention and engagement with the online course.

Keywords: Personalised interventions · Feedback · Student behaviour
Learning analytics · Student engagement · Learning framework

1 Introduction

Providing feedback is an important component of just about all learning contexts. This is even more apparent for online learning systems, where students interact remotely with their course and participate in synchronous and asynchronous modes of learning. In particular, feedback has been strongly related to student achievement and improve the self-awareness, enthusiasm and motivation of students for learning [1, 2]. It is also reported that students have a higher change to become engaged after receiving an intervention [3]. In general, there is a great variety of different types of feedback from formative to summative, immediate to delayed, and which can have both positive and negative effects on learning [4]. As a result, it is essential for online learning systems to provide appropriate feedback mechanisms and strategies that monitor the behaviour of students and automatically provide interventions to support their learning and engagement with the course. In addition, personalised feedback aims to provide students with information and instructions that are most suitable to their learning needs and to the problems they have with their course.

In this paper we present AMASE [5] – a framework that monitors the behaviour of students in an online course and which accordingly triggers automated interventions. In

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this case, a learning course is perceived as a learning activity that combines in a unified manner learning content (that students have to study) and tasks (that students have to perform). The learning activity is generated and personalised by the framework according to the user's prior knowledge, preferences and needs. Advanced monitoring mechanisms are also used to capture and analyse the learner's behaviour and interactions with their course. As a result, we can determine the level of engagement and progress of students, if they struggle with a specific task as well as to identify potential problems with their course. Accordingly, AMASE will trigger suitable interventions that are personalised to student's needs, and which will encourage students to follow the provided recommendations. These motivations take the form of interactive feedback (requiring student input), advices (providing informative instructions), reminders (about events or deadlines) and emails. We believe that such forms of personalised interventions can guide and stimulate students in their online course.

The remainder of the paper is structured as follows: Sect. 2 describes related approaches of how personalised interventions have been used in the field of technology enhanced learning (TEL) and how they may have affected the behaviour and performance of students with their online course. Section 3 presents the AMASE approach and framework to provide automated and personalised interventions to students. Section 4 describes an authentic learning environment where students study an SQL database course and receive interventions. Section 5 investigates how the provided interventions have leveraged the learning behaviour of students. Finally, Sect. 6 summarises the main contributions of our approach.

2 Related Work

Learning Management Systems (LMS) have had a large impact on learning and teaching trends in higher education [6]. Specifically, Personalised Learning Environments (PLE) provide more effective delivery of courses as they can enhance the learning experience of students through tailored content [5]. Widely used LMS are based on asymmetric interactions. In this case, the learner is not prompted to login or engage with their course activities. Instead a level of self-discipline is required and this may become a problem for students that need direction [7]. LMS such as Moodle, Blackboard, Edmodo and others enable instructors to provide learners with feedback and interventions. However, the form of feedback is quite limited. One type of feedback consists of a text area where instructors can provide feedback based on some activity that the learner has completed. Blackboard for example allows instructors to provide learners with feedback for assessments. Another category of feedback supported by popular LMS includes pre-defined feedback which students can see immediately [8]. These assessments are usually in the form of quizzes with answers provided by the instructor and the LMS provides feedback based on the student's answer. Edmodo, for example, allows instructors to create assessment consisting of multiple-choice questions, fill-in the blanks, essay based answers and true/false questions. With the exception of essay based questions (which requires the instructor to correct), the remaining questions can have pre-configured answers provided by the instructor. This allows Edmodo to instantly provide users with feedback as they answer quiz questions.

Although this type of feedback is immediate, it is not adapted to learners nor does it support continuous improvement during the learning process [9].

Vasilyeva et al. [10, 11] discuss the usefulness of presenting learners with elaborated feedback showing correct answers and providing additional information such as corresponding learning materials and explanations. Their study provides adapted feedback using the learner's answers and certitude (answer certainty provided by learner). The evaluation of their study showed that students provided more positive than negative responses about the feedback that was directly shown to them or recommended to them. Lubega et al. [9] discuss the importance of tailoring feedback to the individual learners by monitoring their learning process and assessment results. OFES [8] is a web-based tool that allows instructors to construct student feedback for specific assignments through a feedback template form. The template allows instructors to enter comments and performance related to assessment criteria for individual students. The personalised feedback is provided to learners through a personal feedback space, and graphics showing emotions are included in the feedback to attempt to motivate students. The evaluation of OFES showed that the general consensus amongst students was that the feedback was motivational.

From the related work, it can be seen that feedback and interventions are important aspects of the students' learning experience and most LMS and PLE integrate some form of feedback. However, the feedback is at the discretion of the instructors, where the instructor must provide either through quizzes with pre-configured answers or after an assignment or assessment is completed by the student. In the case of the former, the feedback can be limited; however, it is immediate, automated and can allow some form of personalisation. In the case of the latter, the feedback can be personalised and made motivational for the learner, however, its timeliness is dependent on the instructor and it is not automated. Four feedback factors have been discussed [12] which focus on promoting learning and engagement. These include timeliness (immediate feedback is most effective), motivational (constructive), personalised (in line with students' goals) and manageable (easy to interpret).

AMASE integrates all four factors into its design. In summary, the AMASE framework has been specifically designed to monitor and analyse complex student behaviour and trigger different types of motivations dynamically. The motivations can be triggered instantly, on specific time or interval, or upon the instructor's request. The motivations are elaborate and can take the form of interactive and constructive feedback, informative advices and reminders. In addition, based on student's responses they can be escalated to complex dialogs. They are also personalised to the learning needs, preferences and context of students.

3 AMASE: A Framework for Monitoring and Providing Automated Interventions to Students

AMASE provides a highly dynamic and adaptive framework for the automatic composition, assignment and enactment of personalised learning activities to students [5]. In this context, a learning activity is considered to be an educationally-driven sequence of learning content that the students have to study and user-centric tasks that the students have to perform. In addition, AMASE provides advanced monitoring mechanisms to capture and analyse the learner's behaviour and interactions with their learning environment and course. As a result, we can determine the level of engagement and progress of students, what resources they are using, how much time they spend with specific activities, if they struggle with a specific task as well as to identify their potential problems with the course. Accordingly, the engine will trigger suitable personalised interventions to guide, assist and motivate the students. These motivations take the form of interactive feedback (requiring student input), advices (providing informative text and instructions), reminders (about events or deadlines) and emails (see Fig. 1). We believe that such forms of personalised interventions can provide effective student guidance and feedback as well as stimulate and sustain their engagement in the online course. Finally, the interventions are automatically triggered by the system and sent to students at specific periods (see Fig. 4) and are personalised according to their current progress and engagement with the course.

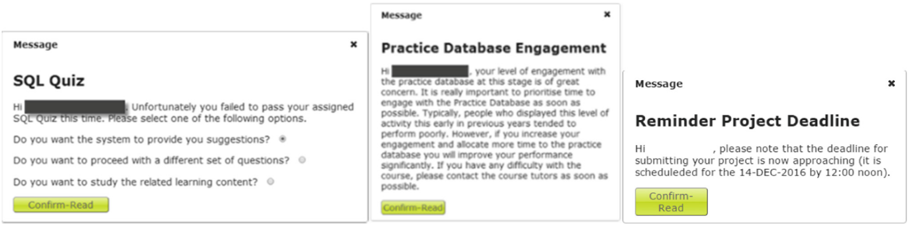

Fig. 1. Personalised interventions are automatically sent by the system to provide feedback to students as well as to promote their motivation and engagement.

4 An Authentic Learning Environment

In order to apply and evaluate our research approach and framework, we created an authentic learning environment, where undergraduate students study a personalised SQL database course. On the background, the learning environment utilises the AMASE framework to compose for each student a personalised version of the course, monitor and analyse their behaviour and interactions with the course as well as to automatically trigger appropriate interventions when it is considered necessary. In this case, the students interacted with their course for a period of 3 months (that is a semester) via the online learning environment (see Fig. 2). This is a type of a blended course, where students also participate in lectures and use the online course in their own time for additional content study, practical activities and course support.

As seen the SQL database course is perceived as a learning activity that is assigned and customised to students. As an example, the learning activity could be described by the following sequence of steps, see Fig. 3. Initially, in the online course we assess the prior knowledge of students on database concepts and accordingly the students are assigned specific content to study based on the evaluation of their learning needs. In addition, as the students' progress with their course, they receive a number of tasks that they have to perform in order, either individually or as part of a team and in parallel to

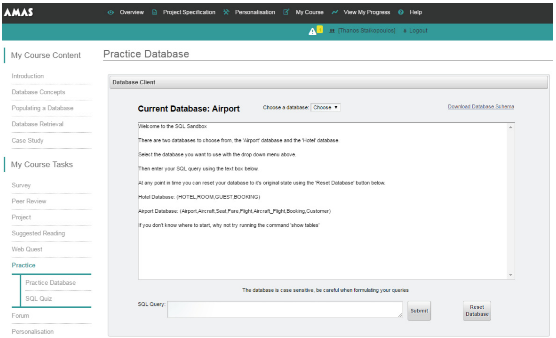

Fig. 2. Learning environment with personalised SQL database course.

their content study. More specifically, first the students are provided with an online SQL environment in which they have to practice and test their SQL skills. In the next phase they will be automatically allocated to groups by the framework and assigned a group activity in which the students will have to find appropriate resources for a given topic and create an audio presentation that will be uploaded to a YouTube channel. Next, the students will be assigned a course project with specific design and implementation instructions and related supporting tools. Finally, the framework will automatically assign three projects to students that were submitted on the previous activity by their peer-students for review.

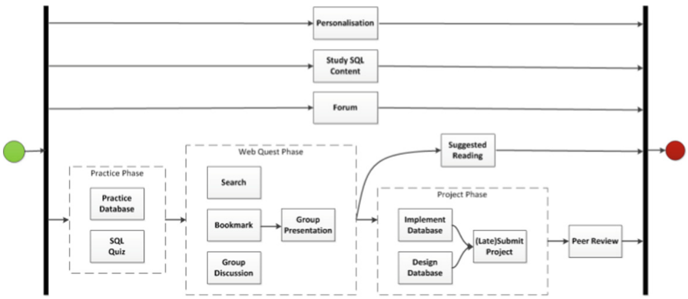

Fig. 3. A sample learning activity (path) for the SQL database course.

As a result, the SQL course is split into two (2) main and parallel parts, the “Study Content” in which the students study their assigned content and another in which they have to perform their practical activities (see Fig. 4). The practical activities are performed in order and corresponding to the following 5 subsequent course phases; (1) the “Practice”, (2) the “Web Quest”, (3) the “Presentation”, (4) the “Project” and (6) the “Peer Review” phases. In each period, the students receive personalised interventions (notifications) regarding their level of engagement and progress with the system.

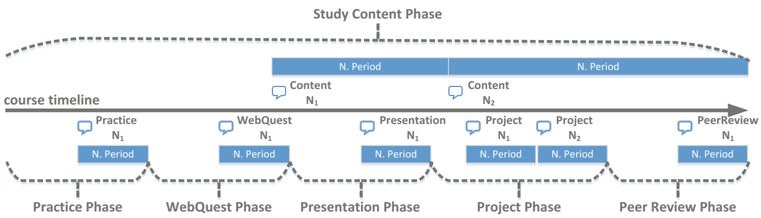

Fig. 4. SQL course phases and interventions.

5 Evaluating the Role of Interventions on Student's Behaviour

In this section we investigate how the automated interventions sent by the system may leverage the learning behaviour of students. The main aim of automated interventions is to guide students with their learning as well as to promote the motivation and engagement of students with the course.

5.1 Student Usage of the Interventions

In the course, the personalised interventions are sent to all students both by email and a message appearing on their learning environment. In general, the students responded well to their interventions by taking on board the advices and working through their assigned tasks. For example, upon the interventions that were related to the practice phase, 72% of the students took the advices (and responded back). On the remaining 28% of the students, 82% of the students read the advices but didn't respond back, where the remaining didn't read or notice their advices.

5.2 Analysing the User Behaviour upon the Received Interventions

This section analyses in more detail how the students reacted once they received the automated interventions from the system. In this case, the interventions sent were assessing the current level of engagement of students. As a result, Fig. 5 depicts the student interactions over the entire course period and in particular over the different course phases and interventions sent to students. In the graph, it is even visually apparent that almost all big spikes were caused by interventions sent during the related course period. For example, once the interventions for the practice phase were sent on day 12, the overall student interactions escalated rapidly and increased from the previous peak (3663) to 11982 (that is 3.27 times higher). Similarly, although not so rapid, was the increase of user interactions for the interventions sent on the web-quest, presentation and review periods. Finally, less but quite noticeable was the increase of interactions for the study content and the project periods.

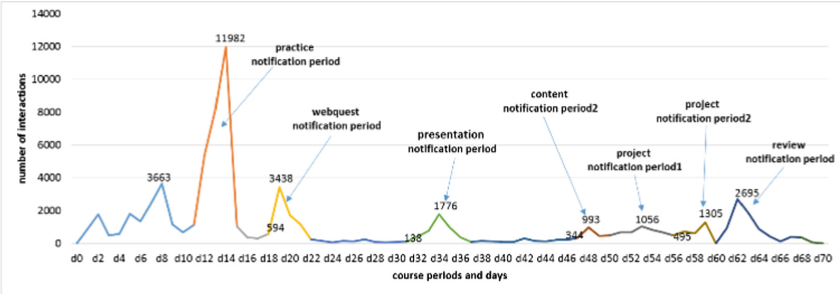

Fig. 5. Student interactions upon the received interventions.

Similarly, Fig. 6 depicts the student duration (study/work time) over the entire course period and in particular over the different course phases and interventions sent to students. As before, it is apparent that once the interventions for the practice phase were sent on day 12, the overall student duration escalated rapidly and went from the previous peak (166244 sec) to 528249 sec (that is 3.18 times higher). Similarly, although not so big was the increase on student's study time once we sent the interventions for the web-quest, presentation and review periods. Also, the increase for the study content and the project phases was more noticeable this time. This is because, in our case the duration is regarded as a more reliable metric of the student behaviour than the interaction with a course material.

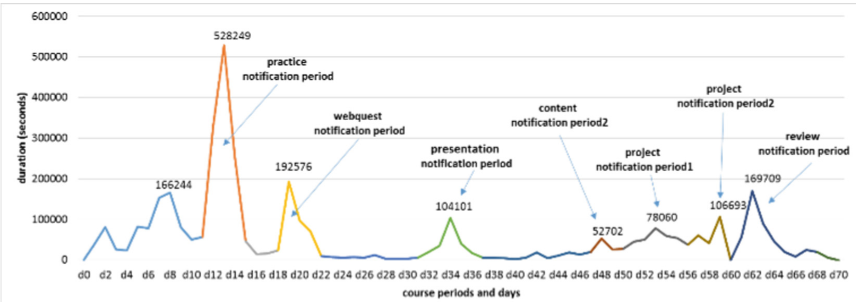

Fig. 6. Student duration upon the received interventions.

Next, in Fig. 7 we depict how the overall level of engagement of students developed over the entire course period and in particular in relation to the interventions sent to students. As before, the overall engagement of students was increased in all cases, however in some course periods the interventions had more impact (see practice and review period). As a result, it appears that the level of increase depends on specific design requirements of the course, for example the nature, volume and weighting of learning content and tasks assigned to students at each course phase.

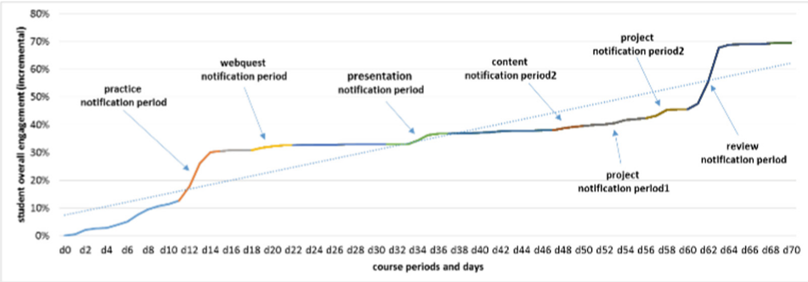

Fig. 7. Student overall engagement increase upon the received interventions.

Finally, in Fig. 8. we depict how the overall level of engagement of students developed over time for the "Practice phase" and compare against a previous year where interventions were not used. In this case, the first intervention took place quite early in order to prepare and alert the students, whereas the second took place later in order to inform the students regarding their current level of engagement. Before the first intervention, the overall level of engagement of students was quite low at 1.62%. Almost at the same time, the year with no interventions the level of engagement of students was 10.42%. Once the first advice was sent, the overall level of engagement increased from 1.62% to 9.73%. At the same time, the level of engagement of students the year with no interventions was approximately 13.39%. As a result, it appears that during this period their difference in engagement had already dropped from 8.8% to 3.66%. Similarly, once the second advice was sent, the overall level of engagement increased rapidly within the following few days, from 9.73% to 52.07%. On the other side, in the corresponding period the year with no interventions, the level of engagement was only 23.74%. If we compare the two periods it appears to have a considerable increase of 28.33% the year where the interventions were used. In particular, the year with no interventions it took students 8 more days to reach a similar level of engagement (54.86%). Subsequently, we believe that personalised interventions can provide the right stimulation to increase the level of engagement of students within a short period of time.

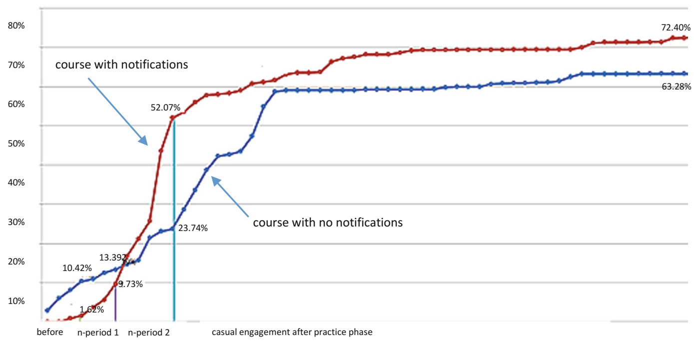

Fig. 8. Comparing student's engagement with and without interventions during practice phase.

5.3 Student's Perception on Interventions and Feedback

Finally, in Fig. 9 we present the results of a questionnaire of how students perceived and experienced the interventions provided to them. The results are based on a feedback that we received from 65 student replies. The 4 questions that fell into that category are the following:

- Q1: "The system provided me with interventions throughout the online course and during different stages". In this case the majority of the students (82.82%, that is 60.94 + 21.88) responded positively to that statement.
- Q2: "The system provided me with interventions about specific course content and tasks at the right times". In this case 56.25% of the students found the timing of the interventions to be correct and appropriate, However, another considerable proportion (26.56%) disagreed (feel they wanted more control).
- Q3: "The interventions send by the system helped me to focus and meet the course deadlines". In this question, the majority of students (53.97%) found the motivations send by the framework help them to meet their course deadlines. However, another considerable population (33.33%) had a different opinion, suggesting that they desired more notice or no notice at all (feel they didn't need to).
- Q4: "I found the interventions send by the system distracting and inappropriate". In this case most of the students (49.23%) found the interventions not distracting and inappropriate. However, another considerable population (32.31%) disagreed.

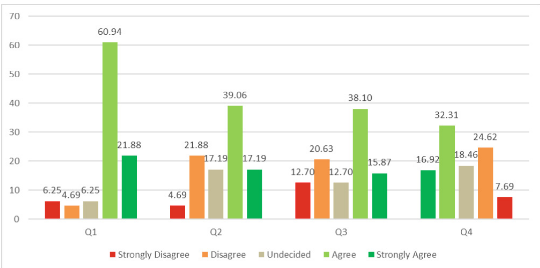

Fig. 9. Student's perception on received interventions.

6 Conclusions

In this paper we presented the AMASE approach and framework which was used to monitor and leverage the online learning behaviour of students while studying a database course with personalised interventions. The aim of interventions was to provide students with automated feedback and guidance as well as to motivate their engagement with the course. In overall, our findings shown the students reacted very positively to the received interventions and different aspects of their online learning behaviour had been considerably increased (leveraged) such as the number of times students interacted with learning resources, study time (duration) and their level of engagement with the course. Finally, the students perceived the received interventions and feedback as very useful to focus on different parts of the course. Even so, there was some students denoted that they would preferred to feel more autonomous and less interrupted to their course. Preferably, for these students it would be better to have the ability to control when the interventions should be triggered.

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References

1. Bellon, J.J., Bellon, E.C., Blank, M.A.: Teaching from a research knowledge base : a development and renewal process, p. 528 (1992)
2. Baek, J., Shore, J.: Promoting student engagement in MOOCs. In: Proceedings of Third ACM Conference on Learning @ Scale, pp. 293–296 (2016)
3. Arroyo, I., Ferguson, K., Johns, J., Dragon, T., Mehranian, H., Fisher, D., Barto, A., Mahadevan, S., Woolf, B.P.: Repairing disengagement with non invasive interventions. In: Proceedings of Artificial Intelligence in Education: Building Technology Rich Learning Contexts That Work, pp. 195–202 (2007)
4. Hatie, H., Timperley, J.: The power of feedback. Rev. Educ. Res. **87**(1), 81–112 (2007)
5. Staikopoulos, A., O'Keeffe, I., Rafter, R., Walsh, E., Yousuf, B., Conlan, O., Wade, V.: AMASE: a framework for supporting personalised activity-based learning on the web. Comput. Sci. Inf. Syst. **11**(1), 343–367 (2014)
6. Coates, H.: A model of online and general campus-based student engagement. Qual. High. Educ. **11**(1), 121–141 (2007)
7. Douglas, I., Alemanne, N.D.: Measuring student participation and effort. In: IADIS International Conference on Cognition and Exploratory Learning in Digital Age (CELDA), pp. 299–302, January 2007
8. Hatziapostolou, T., Paraskakis, I.: Enhancing the impact of formative feedback on student learning through an online feedback system. Electron. J. e-Learn. **8**(2), 111–122 (2010)
9. Lubega, J., Sun, L., Williams, S.: A design for generating personalised feedback in knowledge construction. Adv. Web-Based Learn. **3583**, 302–310 (2005)
10. Vasilyeva, E., De Bra, P., Pechenizkiy, M., Puuronen, S.: Tailoring feedback in online assessment: influence of learning styles on the feedback preferences and elaborated feedback effectiveness. In: Advanced Learning Technologies, ICALT 2008, pp. 834–838 (2008)
11. Vasilyeva, E., De Bra, P., Pechenizkiy, M.: Immediate elaborated feedback personalization in online assessment. In: 3rd European Conference on Technology Enhanced Learning (EC-TEL), vol. 5192, pp. 449–460 (2008)
12. Race, P.: The Lecturer's Toolkit: A Practical Guide to Assessment, Learning and Teaching. p. 248 (2013)

Case Studies

Technology Enhanced Learning for Senior Citizens

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Abstract. Everything is now done online: reading newspapers, talking to friends and relatives, paying invoices and taxes, setting up doctor appointments, etc. As such, competences related to the use of Information and Communication Technologies (ICT) are fundamental. In particular, as mobile technologies and devices such as smartphones or tablets become more and more pervasive and ubiquitous, it is very important to tackle the digital divide issue. And, in a moment where socio-demographic changes resulted in a rapidly growing number of elderly people, it is fundamental to provide them the skills to be connected and integrated in this world. Otherwise, this will not be just a technological disadvantage, but rather a social disadvantage at a societal scale. This article presents a European-wide initiative that addresses this issue by providing technology enhanced training to this target group and an analysis of the achieved results.

Keywords: Ageing · Lifelong learning · Knowledge society · Senior education Mobile technology

1 Introduction

Life expectancy and the share of citizens over the age of 65 years have increased in the recent years. Access to information by senior citizens has to be ensured in order to guarantee their full active incorporation in the society. That is stated in the United Nations Principles for Older Persons, which reflect the need to build an inclusive society that emphasizes participation, self-fulfillment, independence, care and dignity for all [1]. The declaration of principles of the World Summit on the Information Society states the "…desire and commitment to build a people-centered, inclusive and development-oriented society, where everyone can create, access, utilize and share information and knowledge, enabling individuals and communities to achieve their full potential in promoting their sustainable development and improving their quality of life" and explicitly mentions "We shall also recognize the special needs of older persons and persons with disabilities" [2].

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The concept of quality of life for older persons is normally related to their ability to maintain an active and healthy life, with autonomy and independence. Remaining independent is recognized as very important to the quality of life [3, 4].

ICT play a crucial role for the personal and social development and senior citizens cannot afford being excluded from ICT innovations and the positive results generated by the Knowledge Society. However, the emergence of the Digital Knowledge Society created new social inequalities:

- “Exclusion from information or knowledge-based society on the basis of age, gender, origin or socio-economic status represents a new form of social exclusion, the so-called digital divide” [5, 6].
- “The access to and engagement with ICTs is unequally distributed across society leading to a digital divide” [7].

Senior citizens are often info-excluded, as mentioned by Cushman, Klecun and Kiel, that report that there is a much larger proportion of seniors not using ICTs compared to the general population, due to the lack of skills in using those technologies [8, 9]. In fact, it is commonly assumed that the elderly will reject any kind of new technology, like computers, Internet and mobile devices, and are implicitly labeled as digital illiterates. But in most studied cases, the key to technology adoption turned out to be access, information, training and the availability of useful applications. When presented with the opportunity, this population always proved eager to take advantage. Therefore, the problem is not the persons, but other factors such as availability, cost, and usefulness.

UISEL (Ubiquitous Information for Senior Citizens Learning) was a European initiative focusing on allowing senior citizens to develop practical knowledge and skills related to the use of the mobile devices for information access, taxes and fiscal obligations, social security issues, banking, emergency situations, medical monitoring and control and, not less important, for leisure and communication. The novelty of the approach related to the pedagogical methodology, to the use of mobile devices with this target group and also to the actual contents addressed. This article presents the adopted learning methodology and achieved results.

2 Senior Citizens’ Learning

Beyond raising awareness among persons aged 65+ about the benefits in the use of these technologies, UISEL intended to achieve practical learning on how to better exploit them, considering that the senior’s active involvement with technology contributes to the improvement of their health and quality of life [10–12]. Older people, for example, could benefit from access to lower-cost goods and services available online [13]. Or, according to Davidson and Santorelli, these technologies can confer the following social, economic, and health-related benefits [14]:

- Increased connection to family and friends
- Feeling of involvement and relevance to the society

- Access to e-services, such as commerce, personal finances, medication, and employment
- Improved health, wellness, and preventive care
- Benefits to society at large through healthcare savings and senior-related content and services

The pedagogical methodology took in consideration the characteristics of the target audience, namely the fact that they already had years of experience and a wealth of knowledge; they had strongly established values, beliefs, and opinions; they expected to be treated as adults and needed to feel self-directed; they were more interested in straightforward how-to. As such, it relied on the theoretical framework of late life education as proposed by Kolland and Wanka: “Lifelong learning in old age can be defined as personally and socially-motivated experience-based learning. It includes every targeted learning activity that serves to improve skills continuously, abilities and competencies. It can occur both in and outside of organized learning settings. It helps to acquire basic qualifications including digital and practical skills to handle daily tasks better. The objective is self-determination.” [15]. It was accomplished through the definition, development and implementation of a two-stage programme:

1. A training phase based on the immersion in mobile contents and a multimedia environment, which requires collaborative efforts from transnational groups of trainees. This stage was for trainers and caretakers that were in direct contact with senior citizens. It took place through a blended learning methodology integrating face-to-face (f2f) sessions and mobile multimedia contents with the support of an e-platform for collaboration and communication
2. The transfer of the mobile technology appropriation to the senior citizens. This was achieved through direct training by the trainers and caretakers with the support of mobile multimedia modules that also had a self-learning model so that senior citizens could recall how to use any of the mobile devices functionalities.

The methodology was also supported by a mobile app that allowed direct access to the contents and a serious game that allowed developing skills and competences related to the handling of mobile devices. The focus, following Davidoff et al., was to put users in control of the technology and using it to take control of their own lives and enhance choice and independence [16].

The following modules were developed: Introduction to the use of mobile devices, E-government (taxes, finances, social security), E-banking, E-health, E-interaction, E-information and media. The selection of the modules resulted from a previous requirements analysis conducted near the target group.

The model was implemented through a combination of f2f sessions animated by trainers, followed by autonomous work. The e-learning component consisted in accessing the provided UISEL app, going through the tutorial videos proposed and performing a list of suggested e-activities.

3 Results and Discussion

UISEL was implemented in seven European countries: Austria, Portugal, Spain, Slovakia, Czech Republic, Italy and Romania. The seniors' training phase was implemented between May and November 2015 in all seven countries. It counted with the active participation of 233 senior citizens and 27 trainers/caretakers. In total 25 actions with different groups of seniors were organized, in 15 different locations and involving 18 organizations. The evaluation methodology, organized as a case study, aimed at collecting the seniors' and the trainers' feedback, assessing the knowledge acquired by the seniors and getting a general overview of the implementation. The evaluation tools and practices proposed included:

- Applying an initial survey to all the seniors registered in the UISEL course;
- Observing and registering the implementation of the course, taking notes and collecting feedback in an informal way;
- Applying an evaluation survey to all seniors at the end of the course to measure the outcomes and level of satisfaction with the training;
- Performing a semi-structured interview with the trainers.

The first set of questions was aimed at facilitating a general demographic characterization of the UISEL participants. 45% of the participants were aged between 65 and 75 years old. The second largest group, representing 30% of the participants, was aged between 55 and 65 years old. 20% were in the range of 75–85 years old, and 4% were born before 1930, i.e., more than 85 years old.

The majority of participants were women (73%) although an analysis per country shows different realities: in ES men represented 45% and in PT 38% of the participants, while AT, CZ and IT had only 12%, 16% and 19% men participants, respectively.

In relation to the education level, about 40% of seniors completed the high/secondary school level, 30% had a university/college degree and the others had lower qualifications. This data shows that a high educational background is not a condition sine qua non to involve seniors in lifelong learning pathways related with ICT.

Concerning pre-existing health and physical issues (see Fig. 1), only about 35% of the participants (80 out of 233) marked at least one box in this question and the great majority (82%) of these recognized having problems with their eyesight. 9% declared having difficulty in holding their hands steady, while 8% stated having trouble with picking up small things with their fingers. In a positive approach, one might conclude that the majority (the ones that did not sign any box in this question) do not suffer from any age related problems. However, this may not be completely true as it was noticed by some trainers that a great majority did not answer because they perceived the question to be insensitive.

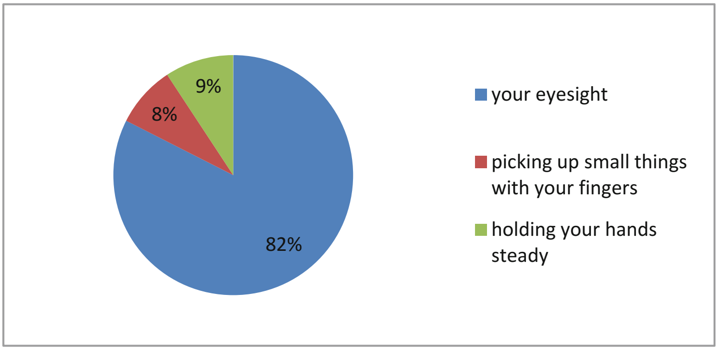

Fig. 1. Health and physical issues

Senior participants answered an initial set of questions in relation to their self-perceived ICT mastery. Their answers are presented in Table 1.

Table 1. Self-perception on ICT mastery

	Initial survey				Final survey			
	Strongly agree	Agree	Disagree	Strongly disagree	Strongly agree	Agree	Disagree	Strongly disagree
I am generally very curious when it comes to new technologies.	99	103	20	1	123	77	18	2
Handling new technologies is hard for me – I am not very good at that.	40	83	70	20	42	96	58	22
If a problem with a technical device occurs, I solve it by myself.	32	78	87	25	25	80	87	28
If I had more competences regarding new technologies, I would use it more frequently than I do right now.	107	80	22	13	111	74	26	11
I fear to break technical devices when I use them.	28	89	67	39	39	80	77	34
When I'm using technical devices, I have no control over what the device is doing.	15	73	92	42	25	54	101	39

UISEL participants were asked to tick the ICT devices used on a regular basis, i.e., at least once a week (see Fig. 2). From the results obtained it was clear that the most used device was the mobile phone (32% of the total number of ticks), followed by the laptop and the PC with 22% and 21%, respectively. The smartphone represents 14% of the ticks and the tablet 12%.

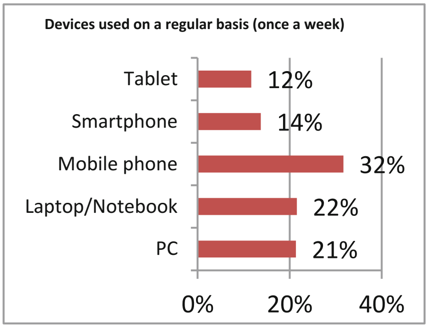

Fig. 2. Use of mobile devices

Seniors' Interest and Acceptance of Mobile Devices

New technologies and mobile devices are an important topic for seniors. It was very easy to recruit senior participants and form groups for the courses. In Austria, each of the courses was fully booked and there was a positive, playful environment in the courses, mainly caused by the seniors' interest but also by the emphasis on group activities and do-it-yourself-activities.

The majority of participants focused on learning how to seek information and how to entertain themselves. Many seniors were happy to be able to communicate with their families and friends who live abroad. In some cases, the motivation driver for the seniors was the will to demonstrate to younger relatives that they were still able to learn new things. The majority considered the tablet a device that better responded to their needs.

UISEL covered a great amount of relevant issues from seniors' daily life, which were adequate to their interests and needs. Seniors were pleasantly surprised that the UISEL course offered a real support in combating isolation and social exclusion. All modules covered their area of interest, which was impressive because they didn't expect it.

Generally, the acceptance of mobile devices during the courses was quite positive, with many participants planning to use a tablet in the future.

Quality of Pedagogical Contents

There was a good combination of materials, all useful and well-structured. Although slides and text guides were commonly used in seniors' training, the use of videos and apps was relatively new and interesting, both from the seniors' and the training organization's perspectives.

The printed contents were perceived to be very helpful and organized but the presentation slides were perceived to be hard to read for senior participants and thus a recommendation to use bigger font sizes and fewer colors.

The feedback on the UISEL app and game was especially positive. The videos and the learning game were used in all courses. Videos were perceived to be helpful for seniors at home as planned in the pedagogical approach, but in a few cases were also used in class. The game was a good instrument to learn first steps on the tablets and was used by all participants during class. In Italy, the UISEL game was considered to be very intuitive and useful for learning touch movement and gain dexterity (even so, some changes are recommended). In Spain, the game seemed too simple for those who already had used tablets, but for those who had never used these devices it was an indispensable tool to learn the basic gestures and skills. Also in Czech Republic the game was considered the most successful resource - being fun for the participants and helping them to feel comfortable with this new technology by understanding the right moves and the way tablets react.

The importance of continuously updating the contents was mentioned. For instance, during the project testing some procedures related to GMAIL functions changed and so the steps showed in the step-by-step guide elaborated months before had to be changed.

Organization of the Course and Pedagogical Approach

The UISEL pedagogical approach was considered appropriate. The combination of learning in class and group repetition was something already practiced generally in senior classes. The inclusion of autonomous learning was a plus that could effectively help the senior remembering some steps that might need further training.

The availability of learning materials in digital format to support autonomous learning was appreciated by the seniors as they had the opportunity to practice on their own. But learning at home is often easier if a family member is available to support, and it is also necessary to make sure that the senior has access to Wi-Fi connection. In class the trainers proposed the videos to support the learning at home, but then it was difficult to verify if it they were effective or not.

In some cases, the e-Learning component was very hard for participants and they did not show particular interest in using the tablets at home autonomously. In other cases, participants were eager to use tablets at home and in free Wi-Fi spaces. Organizations in Austria, in Italy and in the Czech Republic offered weekly learning-meetings in their institutions, where participants could autonomously work with the tablets and use the organization's Wi-Fi. This was perceived to be a good addition to learning in class and self-learning at home. Providing seniors some spare time after or before the class seemed to be more effective and appreciated by them. During the e-learning activities it was important to give trainees the time to repeat the procedure learned in class in an independent way.

In the Spanish group, the availability of learning materials in digital format was quite appreciated by the seniors. They decided to use a local learning platform to offer all students the opportunity to easily access to all materials and that was a very well received. Students were thrilled to use the platform.

It was important to have homogeneous groups in class with participants sharing similar competences and experiences. In this framework, some organizations agreed on a maximum number of participants per group to be able to work with seniors intensively, while others proposed to have two trainers in class, as seniors need theoretical input on one hand but also one-on-one support while learning. But still due to the different level of users' knowledge and dexterity on ICT tools, trainers had to provide one-to-one support and some users were left waiting for the less skilled participants.

Quantitative Assessment by the Senior Participants

Senior citizens also provided quantitative feedback by answering a set of related questions. Their answers can be seen in Figs. 3 and 4.

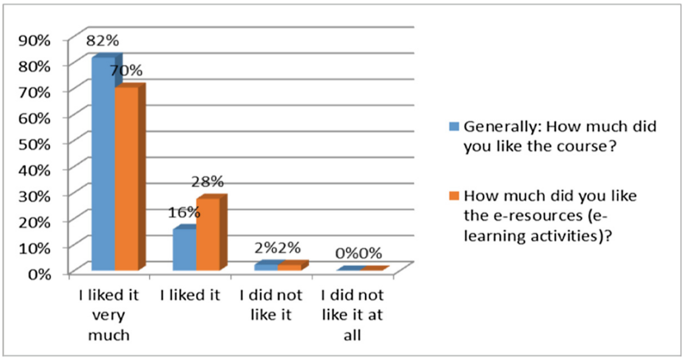

Fig. 3. General satisfaction with the UISEL approach

Overall, when asked if in general terms they liked the course, 98% answered positively (82% liked it very much) and only 2% declared not having liked it. Their feedback on the e-resources (e-learning activities) was quite similar with 98% answering "yes" (70% liked it very much) and only 2% declaring not having liked it.

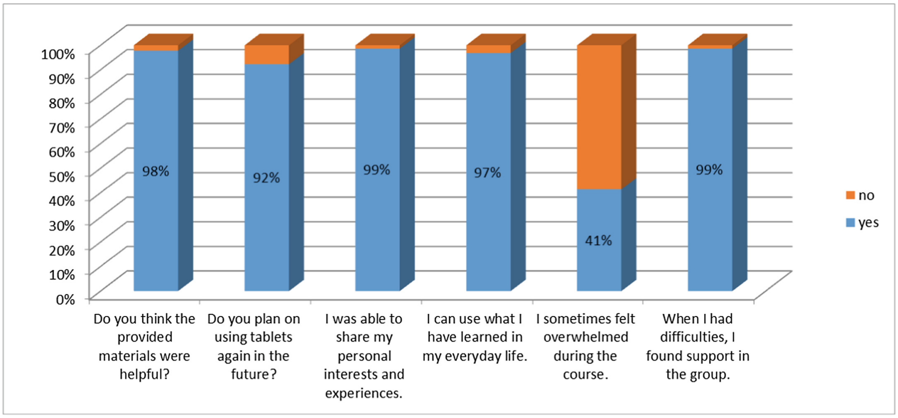

Fig. 4. Specific feedback with the UISEL approach

Practically all the participants answered positively when questioned about the usefulness of the provided materials, the support found in the group, the opportunity to share personal interests and experiences and if they will be able to use what they have learned in their daily lives. 92% answered they plan using tablets again in the future and indeed a few participants have bought their own tablet during the training. The lower rate gathered relates to the question “I sometimes felt overwhelmed during the course” with 41% assuming they did. This means that the general level of the course was challenging for the seniors, which we actually see as a positive aspect because it meant they had to work to achieve success (as most of them did).

4 Conclusions

Socio-demographic changes have resulted in a rapidly growing number of elderly with specific needs and expectations. The need to fully integrate these citizens in the Knowledge and Information Society is a priority. The online information and communication explosion, where everything is digitized from reading online newspapers to paying invoices online, meant that ICT skills are of key importance and a necessity for everyone. However, when it comes to new technologies, like smartphones or tablets, the digital divide becomes even more visible even if the use of mobile devices greatly benefits the seniors as some of the difficulties faced in their everyday life could be better addressed.

The UISEL initiative was designed to tackle these issues through a specific pedagogical approach targeted at this age-group. Its implementation and the research study conducted showed that the courses, the contents and the resources were much appreciated both by senior citizens and trainers and it actually meant positive changes in the participants’ attitudes towards new technologies. Besides the development of curiosity regarding new technologies, the level of self-confidence in the use of technologies has been strengthened as the percentage of people who say they don’t have control over technical devices declined during the course.

Of course, we understand that there are limitations in the study that can prevent generalizing the conclusions extracted by the achieved results. Namely, the fact that most results are of qualitative nature which could in some degree be influenced by the group nature of most of the data collection tools and even by the observation process itself. Nevertheless, we have seen that all the involved senior participants proved to be particularly thankfulness for the opportunity given. They appreciated the utility of the knowledge acquired and most of them plan to use mobile devices systematically. It was therefore possible to ascertain that using technology is not an age-issue but rather a matter of creating the opportunity to know how to use it.

References

1. United Nations: United Nations Principles for Older Persons. http://www.ohchr.org/EN/ProfessionalInterest/Pages/OlderPersons.aspx. Accessed 15 July 2016
2. WSIS: Building the Information Society: A Global Challenge in the New Millenium. http://www.itu.int/net/wsis/docs/geneva/official/dop.html. Accessed 15 July 2016

3. Sixsmith, A., Sixsmith, J.: Smart home technologies: meeting whose needs? J. Telemed. Telecare, **6**(1) Supplement, 190–192 (2000)
4. Gilhooly, M., Gilhooly, K., Jones, R.: Quality of life: conceptual challenges in exploring the role of ICT for ageing. In: Cabrera, M., Malanowski, N. (eds.) Information and Communication Technologies for Active Ageing in Europe. IOS Press, Amsterdam (2013)
5. Castells, M.: La era de la información: Economía, sociedad y cultura, Vol. III, Siglo XXI Editores, Mexico, Argentina, Spain (2004)
6. Van Dijk, J.: The Network Society, 3rd edn. Sage Publications Ltd., London (2012)
7. Korupp, S.E., Szydlik, M.: Causes and trends of the digital divide. Eur. Sociol. Rev. **21**(4), 409–422 (2005)
8. Cushman, M., Klecun, E.: Non-users of computers in South London. Their experiences and aspirations for their use. Department of Information Systems, London School of Economics and Political Science, London (2006)
9. Kiel, J.M.: The digital divide. Internet and e-mail use by the elderly. Med. Inform. Internet Med. **30**(1), 309–323 (2005)
10. Blažun, H., Saranto, K., Rissanen, S.: Impact of computer training courses on reduction of loneliness of older people in Finland and Slovenia. Comput. Hum. Behav. **28**(4), 1202–1212 (2012)
11. Chen, Y., Lee, B., Kirk, R.M.: Internet use among older adults: constraints and opportunities. In: Zheng, R., Hill, R., Gardner, M. (eds.) Engaging Older Adults with Modern Technology: Internet Use and Information Access Needs, Hershey, PA, pp. 124–141. Information Science Reference (2013)
12. Sum, S., Mathews, R.M., Hughes, I., Campbell, A.: Internet use and loneliness in older adults. CyberPsychol. Behav. **11**(2), 208–211 (2008)
13. McLean, R., Blackie, N.M.: Customer and company voices in e-Commerce: A qualitative analysis. Qual. Market Res.: Int. J. **7**(24), 243–249 (2004)
14. Davidson, M.C., Santorelli, J.M.: Network effects: An introduction to broadband technology & Regulation. U.S. Chamber of Commerce, Washington D.C. (2008)
15. Kolland, F., Wanka, A.: Learning in later life. In: Field, J., Burke, R.J., Cooper, C.L. (eds.) The SAGE Handbook of Aging, Work and Society. SAGE, Los Angeles (2013)
16. Davidoff, S., Lee, M.K., Yiu, C., Zimmerman, J., Dey, A.K.: Principles of smart home control. In: Dourish, P., Friday, A. (eds.) UbiComp 2006. LNCS, vol. 4206, pp. 19–34. Springer, Heidelberg (2006). https://doi.org/10.1007/11853565_2

A Study of Students' Conception of Problem Situations: Using Conceptualization in Scenario-Based Learning

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Abstract. Students' appropriate conception of a problem situation can support improved problem solving in both self-regulated learning and STEM disciplines and can support the self-understanding which is the principal competency for self-regulated learning. The current study focused on students' conceptualization of ten problem situations, half being Sequential (SEQ) and half being Non-Sequential (NonSEQ). Student participants conceptualized the problem situations using their own diagrammatic techniques. It was hypothesized that self-regulated learners can successfully conceptualize either problem situation. The results revealed that, while there was no significant difference between conceptualizations whether participants started with SEQ or NonSEQ situations, subsequent conceptualizations were significantly poorer for SEQ versus Non-SEQ situations.

Keywords: Conception · Conceptualization · Conceptual reasoning STEM · Self-regulated learning · Technology-enhanced learning

1 Introduction

Conceptualization and conceptual reasoning are particularly relevant for the STEM disciplines (Science, Technology, Engineering, and Mathematics) [2, 3]. In order to learn a STEM discipline effectively, students should be able to master a variety of STEM representations and be able to translate them into other representations [1]. It is hypothesized that students will learn a STEM subject better if their conceptual representations are precise, clear, and appropriate.

Different types of representation in real-world problems have different strengths and weaknesses [1]. There are many types and techniques of representation for entities in a domain of interest. For example, mathematical equations represent the quantitative

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measurement of variable sets, process diagrams formalize business procedures and business rules, and Entity-Relationship diagrams visualize the relationships among data objects.

In this research, the diagrammatic conceptualization of problem situations was the main concern. The paper presents an overview of the theoretical background in Sect. 2, describes the experimental study of students' conceptions in problems situations in Sect. 3, and the conclusion of the study is summarized in Sect. 4.

2 Theoretical Background

2.1 Conceptualization

Conceptual representation using graphical or diagrammatic techniques is way to improve humans' capacity to construct knowledge [4, 14]. Many research studies focus on how to conceptualize real-world problems and situations in ways that support humans with problem solving and decision making. Interestingly, Keogh and Naylor [12] introduced "concept cartoons" as a tool for teaching and learning, and proposed their use as an innovative teaching strategy to capture the learners' attention in order to promote learning and stimulate them to focus their attention on creating meaningful explanations and thus creating knowledge.

2.2 Students' Conception

Students studying STEM subjects need to apply soft-skills to determine appropriate representations of specific problem situations to support problem solving, and need to appreciate the strengths and weaknesses of different representations.

Burnett et al. studied the influence of conception of learning and self-conception of students on choosing appropriate approaches for their learning [8]. Burnett identified surface learning, memorizing, and reproducing, and deep learning, understanding and seeking differences and changes. Purdie et al. studied the relationship between students' conceptions of learning and self-regulated learning strategies in different cultures [9]. Purdie reported that Australian students' conceptionstended towards memorizing and reproducing, whereas Japanese students' conceptionstended towards acquiring knowledge and fulfilling personal requirements. The strategies of learning for both groups were different but shared the use of memorization. Japanese students seemed to show independence in learning by using different strategies more than Australian students. Alamdarloo et al. [11] studied the relationship between students' self-conceptions of learning and their success in studying, and found that there is a significant relationship between students' conceptions and their academic achievement; the finding confirms that the higher level of students' conceptions in learning representing in the hierarchical structure leading to obtain the better learning results [10, 11, 13].

2.3 Self-regulated Learning

Self-regulated learning has been defined as self-generated thoughts, feelings, and actions, which are consistent with the learners' objectives [5, 7]. Theoretically, it is a powerful construct that provides researchers and educators a perspective on the variety of factors influencing successful learning [6]. The self-regulated learner should be able to apply controllable and systematic methodologies for achieving desired learning outcomes.

3 A Study of Students' Conception in Problems Situations

3.1 Research Question

The research question was, "Can learners conceptualize problem situations using their own diagrammatic techniques?".

3.2 Students' Conceptualizations in Scenario-Based Learning

Ten problem situations were prepared for the study (see Table 1).

Table 1. Ten scenarios used in the study

	Scenario description	Conceptualization
1	Daily life	NonSEQ
2	Simulated story	NonSEQ
3	Business	NonSEQ
4	Natural disaster	NonSEQ
5	Kindergarden	NonSEQ
6	Cyber security	SEQ (Workflow)
7	Market basket	SEQ (Usecase)
8	Food recipe	SEQ (Flowchart)
9	English language learning	SEQ (Flowchart)
10	STEM education	SEQ (Flowchart/Usecase)

Each situation, called a scenario, was designed to explore how well students understood the problem and was able to interpret it using a diagram. Five SEQ scenarios outlined problems involving sequences or step-by-step activities, and 5 NonSEQ scenarios outlined problems involving non-sequenced concepts or data.

3.3 Procedure

Participating students were enrolled at a large and top university in Thailand and undertook the study in class. All 136 participants (N = 136) were voluntary undergraduate students (aged from 19 to 21 years; 69 females, and 67 males).

Participants first received a short lecture on diagrammatic conceptualization, and were then asked to read the provided scenarios and draw a diagram appropriately conceptualizing the problem in each.

Approximately half of the participants (N = 64) first attempted the five NonSEQ scenarios before doing the SEQ scenarios, while the other half of the participants (N = 72) attempted the SEQ scenarios first.

After the experiment was completed, participants were given feedback from the first author who revealed the lessons that should be learned from the diagramming activity.

3.4 Rubric for Conceptual Knowledge Assessment

The meaningfulness of the resulting diagrammatic conceptualizations was assessed, being scored 0 (showed no understanding of the problem scenario concepts) or 1 (identified all important concepts). Each participant received a total score between 0 and 5 for their five NonSEQ diagrams, and similarly a score between 0 and 5 for their SEQ diagrams.

For example, in order to diagram the "Food recipe scenario", a participant might have drawn the diagram illustrated in Fig. 1. This was scored "1" because it represented all the important concepts related to baking a cup-cake.

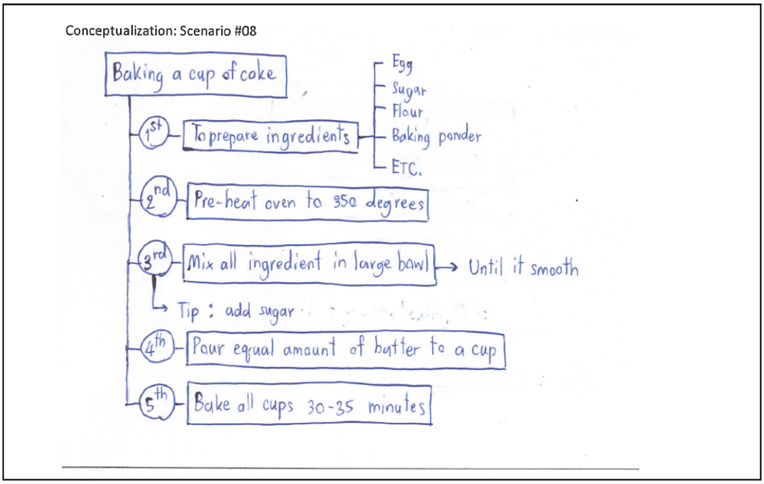

Fig. 1. Example of a participant's drawing result for scenario no. 8

3.5 Experimental Results

This experimental study investigated whether there was a significant difference between the SEQ and NonSEQ scores (scenario type), whether there was a significant difference in scores between participants who undertook the NonSEQ scenarios first and those who undertook the SEQ scenarios first (presentation order), and whether there was a significant interaction between presentation order and scenario type.

The results revealed that the interaction effect was significant, suggesting that any differences between the scores of participants undertaking the SEQ versus the NonSEQ scenarios depended upon whether they undertook the scenario first or second.

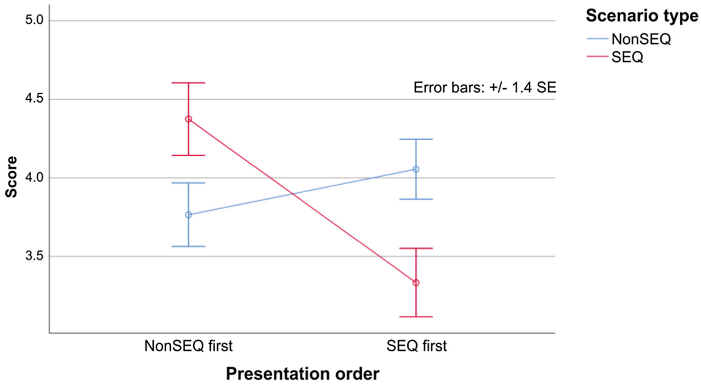

Fig. 2. Profile plot for scenario type

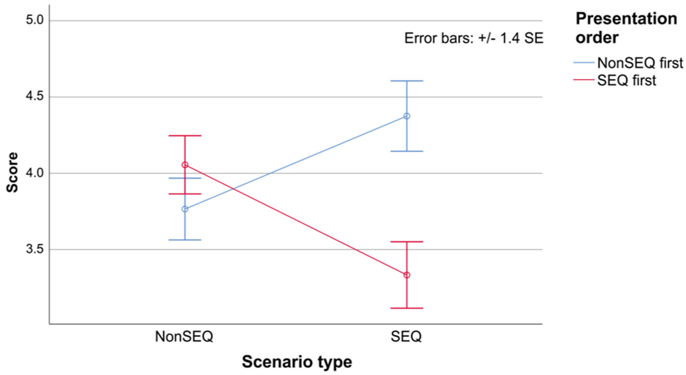

Fig. 3. Profile plot for presentation order

Figure 2 shows that the SEQ score of participants who undertook the NonSEQ task first was significantly higher than the NonSEQ score of participants who undertook the NonSEQ task first, and that this difference was reversed such that the SEQ score of participants who undertook the SEQ task first was significantly lower than the NonSEQ score of participants who undertook the SEQ task first. Figure 3 shows that the NonSEQ score of participants who undertook the NonSEQ task first was not significantly different from the NonSEQ score of participants who undertook the SEQ task first; while the SEQ score of participants who undertook the NonSEQ task first was significantly higher than the SEQ score of participants who undertook the SEQ task first.

4 Conclusion

This article investigated the competency of self-regulated learners studying a STEM subject, to diagrammatically conceptualize problem situations.

The experimental study allowed students to draw their own diagrams and compared the results between sequential situations (SEQ) and non-sequential situations (Non-SEQ). The results showed that presentation order was significant for SEQ scenarios but not for NonSEQ scenarios, suggesting that the teaching of appropriate conceptualizations and diagrams for problem situations involving step sequences may need to carefully distinguish such conceptualizations from non-sequencing problems.

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References

1. Prain, V., Waldrip, B.: An exploratory study of teachers' and students' use of multi-modal representations of concepts in primary science. Int. J. Sci. Educ. **28**(15), 1843–1866 (2006)
2. Meter, P.N., Firetto, C.M., Rurns, S.R., Litzinger, T.A., Cameron, C.E., Shaw, C.W.: Improving students' conceptual reasoning by prompting cognitive operations. J. Eng. Educ. **105**(2), 245–277 (2016)
3. Watson, M.K., Pelkey, J., Noyes, C.R., Rodgers, M.O.: Assessing conceptual knowledge using three concept map scoring methods. J. Eng. Educ. **105**(1), 118–146 (2016)
4. Carney, R.N., Levin, J.R.: Pictorial illustrations still improve students' learning from text. Educ. Psychol. Rev. **14**(1), 5–26 (2002)
5. Zimmerman, B.J., Schunk, D.H.: Self-Regulated Learning and Academic Achievement: Theory, Research, and Practice. Springer, New York (1989). https://doi.org/10.1007/978-1-4612-3618-4
6. Boekaerts, M.: Self-regulated learning: a new concept embraced by researchers, policy makers, educators, teachers, and students. Learn. Instr. **7**(2), 161–186 (1997)
7. Zimmerman, B.J.: Self-regulated learning and academic achievement: an overview. Educ. Psychol. **25**(1), 3–17 (1990)
8. Burnett, P.C., Pillay, H., Dart, B.C.: The influences of conceptions of learning and learner self-concept on high school students' approaches to learning. Sch. Psychol. Int. **24**(1), 54–66 (2003)
9. Purdie, N., Hattie, J., Douglas, G.: Student conceptions of learning and their use of self-regulated learning strategies: a cross-cultural comparison. J. Educ. Psychol. **88**(1), 87–100 (1996)

10. Martinez-Planell, R., Gonzalez, A.C., DiCristina, G., Acevedo, V.: Students' conception of infinite series. Educ. Stud. Math. **81**, 235–249 (2012)
11. Alamdarloo, G.H., Moradi, S., Dehshiri, G.R.: The relationship between students' conceptions of learning and their academic achievement. Psychology **4**(1), 44–49 (2013)
12. Keogh, B., Naylor, S.: Concept cartoons, teaching and learning in science: an evaluation. Int. J. Sci. Educ. **21**(4), 431–446 (1999)
13. Pantziara, M., Philippou, G.: Levels of students' conception of fractions. Educ. Stud. Math. **79**, 66–83 (2012)
14. Tangworakitthaworn, P., Gilbert, L., Wills, G.: Using conceptualisation of intended learning outcomes as facilitators to support self-regulated learners in indicating learning paths. J. Comput. Assist. Learn. (JCAL) **31**(5), 393–404 (2015)

Investigating Users' Decision-Making Process While Searching Online and Their Shortcuts Towards Understanding

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Abstract. This paper presents how we apply Exploratory Search KiP model, a model capable of assisting the visualization of search patterns and identifying best practices associated to users' decision-making processes, to log analysis and how it helps understand the process and decisions taken while carrying out a search. This study aims to model searches performed through web search tools and educational resources portals, to enable a conceptual framework to support and improve the processes of learning through searches. Applying the model to log analysis, we are able: (1) to see how the information retrieved is used to define decision criteria about which data are worth extracting; (2) to draw inferences and shortcuts to support understanding; (3) to observe how the search intention is modified during search activities; and, (4) to analyze how the purpose that drives the search turned into real actions.

Keywords: Exploratory search · Knowledge-intensive process
Web searching · Web-based learning · Search pattern
Search decision-making process

1 Introduction

As computers become ubiquitous and the internet is the locus of convergence for mass media, searching the web becomes more than a habit for a wide range of people. In this sense, defining exploratory search is no easy task, since the majority of searches are, in some way, exploratory. According to White and Roth [10], those searches are motivated by complex information problems and accompanied by misunderstandings about terminology and information structure. In any case, the basic motivation behind any Web search is a desire to know which exploratory strategies are used to allow new associations, to discover knowledge, and to aid user's decision-making regarding worthy content and paths to obtain it. These are important characteristics to learning.

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A common feature in an exploratory search scenario is that users usually do not have enough previous information to help them define a structured query [4, 7, 10]. Although lack of information is in itself a major challenge to any search, users' own searching skills and knowledge of the context contribute to narrowing this gap and facilitating a continuous flow of data gathering that can lead to learning. In this sense, users' behavior and the tasks they choose to perform are of great importance to achieve a successful outcome. This is so relevant that user's previous search experiences and background are pivotal to understanding search intentions and information acquisition patterns. Under these circumstances, exploratory searches can be considered a Knowledge-Intensive Process (KiP).

KiP enables to understand and represent a knowledge-intensive process rather accurately. The Knowledge Intensive Process Ontology (KIPO) helps providing concepts to represent and improve the understanding of KiPs [3]. The relevance of the ontology in this study lies in exploring elements from tacit knowledge [3] and using them to represent KiP's features accurately. KIPO fulfills this role well because it already has a specific graphical notation to represent tacit knowledge, the Knowledge Intensive Process Notation (KIPN). This notation is presented and explained thoroughly in [5, 6], but here we summarize the main features related to a set of diagrams used to represent search/user perspectives within a KiP.

The first of these diagrams is the KiP Diagram, which indicates constraints to the flow as well as represents circumstantial events, innovations and decisions. Another diagram is the Socialization Diagram, which has the role of showing how knowledge acquisition and sharing takes place within activities. There is also the Decision Diagram, which has the aim to match detailed decision-making processes with their respective results. Finally, there are three last sets of diagrams. An Agent Diagram maps the agents' experience and expertise and illustrates their skills; an Intention Diagram represents desires, feelings and beliefs that motivate an agent to engage in activities, decisions or socializations; and a Business-Rules Diagram represents documented business rules that limit a decision during a Knowledge-intensive Process (e.g., legislation, contracts, and internal regulations[1]).

Wildemuth and Freund [11], and White and Roth [10] have identified attributes (cognitive and behavioral) and activities (lookup, instruction and investigation) observed during an exploratory search and used them to build more efficient search engines. As a KiP, these attributes and activities should also be used to map activities connected to knowledge acquisition, sharing, storage and reuse. Exploring the intricacies of this process contributes to understanding how exploratory search relates to learning.

Exploratory search as a KiP involves visualizing its tasks as part of a chain of actions that, consistently performed, helps clarify reasons behind search tasks, meanings attributed to the information retrieved and how it is used to promote user's awareness about the subject. We note that this is the very definition of exploratory search, shared by authors such as Vakkari [7, 8], White and Roth [10] and Wildemuth

[1] In our context, informal regulations/conventions that are part of the professional knowledge of users are very relevant.

and Freund [11]. Since this is an activity in which uncertainty plays a fundamental role and in which a berrypicking pattern [1], with bit-by-bit information gathering, it is necessary to create systematic awareness about a situation or fact, a search quest can lead to many paths, but not necessarily, those connected to learning. In order to develop more assertive search tools that can be used as learning tools, on the bases of studies exploring concepts such as Searching as Learning [9] and Information Seeking [4], it is necessary to view knowledge as an integral part of the process.

In this paper, we briefly present the Exploratory Search KiP model: it is an exploratory search model that views search tasks and activities as part of an action chain that helps understand the process developed and decisions taken while a particular subject is sought for, and how users use the information retrieved to develop their own awareness of the topic. Then, we present how we applied the model to log analysis and how this helped visualizing search patterns and the elucidation of best practices associated to users' decision-making processes. Our study aims to model searches performed through web search tools or portals of educational resources, in order to understand users' search and decision processes, their intentions and navigation patterns. Our ultimate goal is being able to propose for a further stage of the research, a conceptual framework that could account for the processes of learning that occurred during searches. The paper is organized as follows. Section 2 explores the Exploratory Search KiP Model as a way to identify users' decision-making process. Section 3 discusses the possibility to generalize the Model by sharing insights from its application to log analysis. Finally, Sect. 4 concludes the paper and suggests future developments.

2 Exploratory Search KiP Model as a Way to Identify User's Decision-Making Process

The Exploratory Search KiP model was tested and revised in a collaboration between Italian, German and Brazilian Universities, using data from a previous study conducted by Bortoluzzi and Marenzi [2], where six expert teachers from different Italian school levels were selected and observed while searching online resources on the Web through think-aloud protocols[2] and interviews in which they commented on their search habits and choices. During the design process, an earlier version of the KiP model presented problems in capturing the contextual relevance of the variables involved (i.e. what kind of resource the user is looking for and for what purpose) and the personal expertise used by the teachers as filters for the search.

The KIPN symbols were adapted to reflect adequately users' actions and identify the key elements to represent according to the context of each specific search. Searching for resources online is not a simple task, especially when these resources will be used for teaching or learning purposes. In such cases, the search involves not only contexts about the searched subject, but also the user's knowledge of the educational

[2] The protocol involves that participants describe aloud what they are thinking while performing a set of specified tasks.

context and the professional expertise about what is best suited to achieve his/her goals, learning preference or teaching style. Explanations by each user during their think-aloud protocol were also analyzed in detail along with the visual observations of their actions during their searches.

To address this challenge, instead of focusing on modeling a process overview (i.e. verifying how the process activities proceeded from one point to another), we decided to observe how the search intention was modified during the activities, analyzing how the purpose that prompted the search turned into real actions. Detailing the activities allowed us to perceive the desire (or rather the purpose derived from a task in our research context) that triggered the search and how it evolved along the search, revealing the intentions behind every action or decision made. It was also possible to see how the chosen terms or keywords changed and whether this change was related to a refinement of the previous term or a modification of the term itself, indicating a change of direction in the search.

Another challenge was to find a suitable way to describe the actions taken by users during their searches. KIPN visual icons and images helped, but they were not sufficient for the purposes of this study. The explanations given during the think-aloud protocols led us to include labels and comments that can better capture and represent the actions and comments made. More information about the model refinement can be found in [12].

3 The Exploratory Search KiP Model Applied to Log Analysis

3.1 Investigating Users' Exploratory Search Patterns

One of the features we noticed during modeling was that by looking at the exploratory search as a KiP, we were able to visualize the search pattern that aided each user to find the right resources and helped them define decision criteria about which data are worth extracting. We achieved this by integrating the KIPN's Intention Diagram into each search activity presented by the model [12]: (1) Search Term Selection; (2) Query Formulation; (3) Results Check and (4) Information Extraction.

By visualizing how the purpose that prompted the search became intentions and how intentions influenced the search activities, we also saw the formation and refinement of a mental image regarding the subject sought. Mental image, in this context, can be defined as an understanding about the subject capable of empowering rational arguments and increasing one's awareness. It also contributes to understanding how the search intention is modified during search activities allowing the analysts to get insights into how users' decision process are related to the links they chose to click, the terms they included in their queries, and how this specification helped them refine the search results.

In order to investigate if it was possible to apply the model to data for which we had a less in-depth level of context knowledge than we had for the think-aloud protocol data, and to check to what extent is it possible to generalize the model (and its applicability in less specific situations than those reported here), we decided to use the model to analyze search logs. The logs were collected from an online professional community of student teachers and expert teachers during a workshop aimed to investigate how teachers search for and tag online resources for their teaching practice.

From the data of 52 activities stored in transaction logs of this online teacher professional community, we mined the ones related to Exploratory Search activities as presented in our model (from a total of 22 users performing 1,249 search sessions). In order to do that, we selected not only the activity description but the parameter involved (e.g. "searching" activity implied the parameter "query"). The correlation is described in Table 1.

Table 1. Logs and Exploratory Search KiP model activities correlation.

Activities from the logs	Exploratory Search KiP model activities
"searching" and "group resource searching"	Corresponding to "search term selection" and "query formulation" activities
"opening resource"	Corresponding to "results check" activity
"downloading"	Corresponding to "information extraction" activity
"tagging resource"	A measurement of understanding. If the user can assign tags, this action shows understanding of the subject searched and the resource selected

3.2 The Model as a Guide to Understand Logs

Figure 1 shows a sample taken from one of the sessions performed by *User 11270* and modeled as an Exploratory Search KiP. It is possible to observe the specialization of the search term from a general one ("metaphor") to a more specific ("metaphors for learning" and "metaphors for language teaching"). For comparison purposes, Fig. 2 shows the sequence of actions captured by the logs for the session.

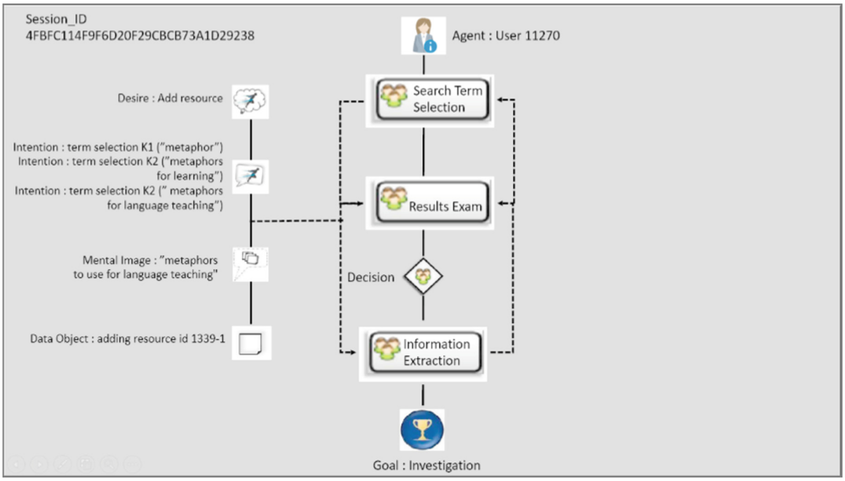

Fig. 1. Sample of an Exploratory Search KiP modeled for one of the sessions.

The pattern captured by the modeling corresponds to the timestamp "2017-11-22 12:00:22" through "2017-11-22 12:10:48". In this space of 10 min, it is possible to identify the formation of a mental image based on the terms "metaphors" for learning and for language teaching, which resulted in the addition of a resource represented by the extraction of the data object *"resource id 1339-1"*, shown in Fig. 3. It was possible to observe how the purpose that drives the search (find a resource available in this online professional community and add it to the user's repository) turned into real actions (the definition and refinement of terms from "metaphor" to "metaphors for language teaching").

	user_id	session_id	action	params	timestamp	term_criterion_label
2	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	32	'404891'	'2017-11-22 11:54:20'	downloading
7	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'metaphor'	'2017-11-22 12:00:22'	K1
8	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'metaphors for learning'	'2017-11-22 12:02:37'	K2
9	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'metaphors for language teaching'	'2017-11-22 12:03:56'	K2
11	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'metaphors for language teaching'	'2017-11-22 12:09:41'	K2
12	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	15	'1339 - 1'	'2017-11-22 12:10:48'	adding_resource
13	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'mobile apps'	'2017-11-22 12:12:30'	K4
14	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'french'	'2017-11-22 12:12:57'	K4
15	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'dictionary'	'2017-11-22 12:13:08'	K1
16	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'dictionary'	'2017-11-22 12:13:10'	K1
17	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	52	'ALL(25)'	'2017-11-22 12:13:14'	group_category_search
171	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	52	'ALL(25)'	'2017-11-22 12:13:14'	group_category_search
18	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'dictionary'	'2017-11-22 12:13:18'	K1
19	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'french dictionary'	'2017-11-22 12:13:31'	K2
20	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'peer teaching'	'2017-11-22 12:14:51'	K4
21	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	34	'blog'	'2017-11-22 12:15:20'	K1
26	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'tips for learn english'	'2017-11-22 12:21:55'	K3
27	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	5	'games for learning english'	'2017-11-22 12:24:26'	K3
28	11270	'4FBFC114F9F6D20F29CBCB73A1D29238'	15	'1371 - 1'	'2017-11-22 12:27:36'	adding_resource

Fig. 2. Logs from the session listed by timestamp.

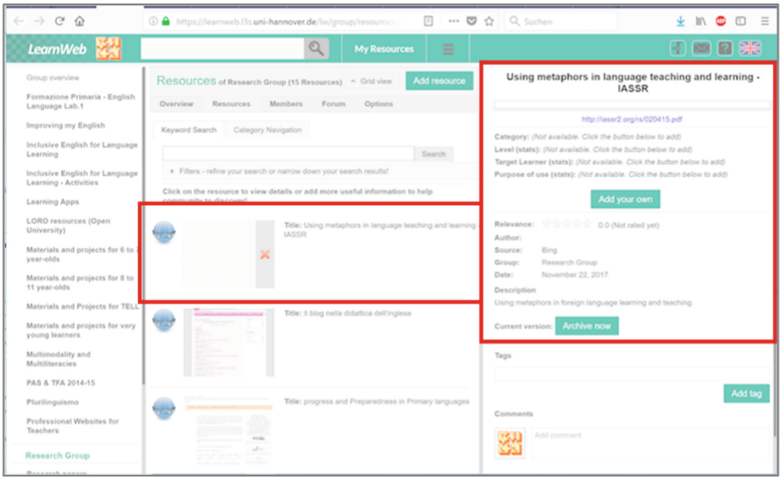

Fig. 3. The resource added to the online professional community.

The activities “searching” and “group resource search” from the logs were related to Exploratory Search KiP Model activities “Search Term Selection” and “Query Formulation” because they displayed keywords or more structured queries that could be mapped using the Term Criterion Labels presented in the Exploratory Search KiP Model’s Decision Diagram. The Term Criterion Labels are categorized into four kinds: (K1) related to a general term or keyword; (K2) a more specific term related to K1; (K3) also a more specific term, but not related to K1; (K4) term not related to the subject. By using them to map the search pattern presented in Fig. 2, it is possible to observe a search profile displayed by the user to draw inferences and shortcuts to support his/her understanding. In this case, a refinement from general term (K1) to a specific one (K2), followed by a change of subject (K4) until his/her decision to use a more specific subject not related to the general term previously used (K3), but better suited to put into action his/her intention (implying a broader awareness about the subject than before). “Opening resources” was related to the “Results Check” activity based on its link-click property and the log’s “downloading” activity, as one of the ways we used to characterize “Information Extraction”.

Our analysis was performed using R Programming to stabilize the data and Google Charts to compare users search activities to Exploratory Search KiP Model activities. The overall percentages of actions, calculated by adding the frequency of each action performed by users in every session, show that the “Results Check” activity (opening resource) from Exploratory Search KiP Model is essential to enable users to select sources by quality and relevance and extract the resources (downloading), as Fig. 4 shows.

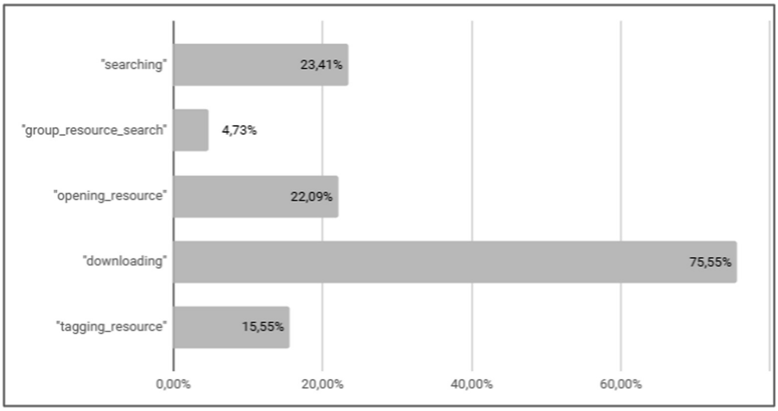

Fig. 4. Overall percentage of actions performed by users.

Although correlating the action of opening resources to the action of downloading them seems natural, observing the users individually shows a different story. It is possible to notice that the frequency of resources opened by users during their sessions indicates that the “Results Check” activity is not performed each time information is retrieved during a search. In addition, the frequency of downloading resources indicates that users did not necessary examine a result through link-click to decide about its suitability as a data object worth retrieving: as shown in Fig. 5, three users downloaded resources without opening them previously. In these cases, the users' decision criteria seem to be more deeply internalized or tacit to the point that checking the content becomes unnecessary.

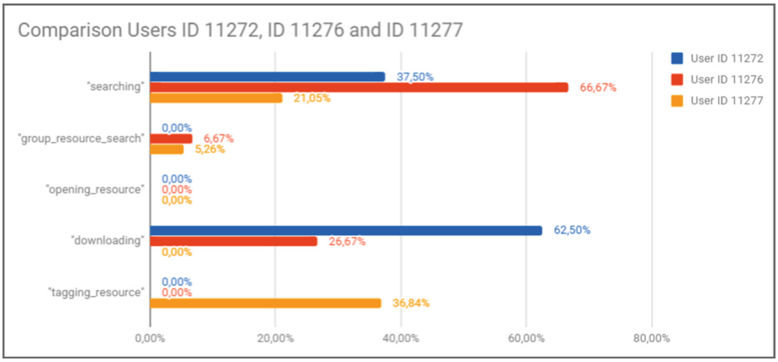

Fig. 5. Percentage of actions performed by users 11272, 11276 and 11277.

This pattern correlates with calculating the frequency mean of the actions analyzed. Figure 6 shows a percentage reduction in action opening resource (15.63%) comparing to Fig. 4 (22.09%).

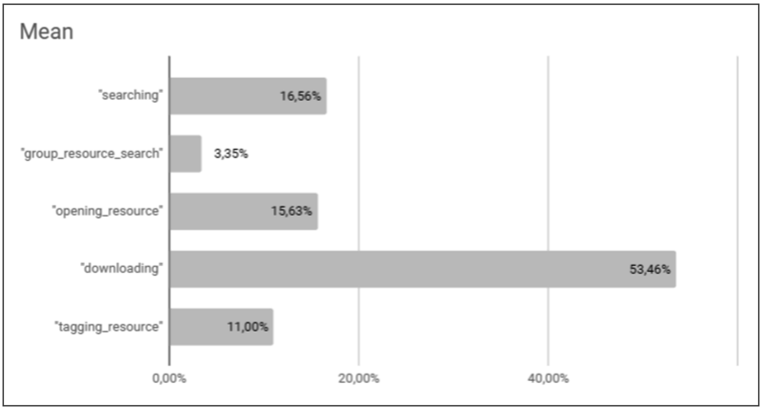

Fig. 6. Frequency mean percentage of actions performed by users.

Performing a series of scatter plots drawn from our analysis, we were able to see a synchronicity of actions (a characteristic of Exploratory Search KiP Model). Although not all actions were performed by every user, the frequency of the actions performed indicates an Exploratory Search KiP pattern. In Fig. 7, we can see in a clearer way the frequency of the searches performed by users and distributed through the sessions. Although the parameter associated to these activities was the search query itself, by analyzing the sequence of actions from each session and its parameters we realized that sometimes searching actions are not performed only using terms and queries, but also by link clicking and browsing through selected categories. This indicates that Exploratory Search KiP activities sometimes can occur in parallel (e.g. searching by examining results).

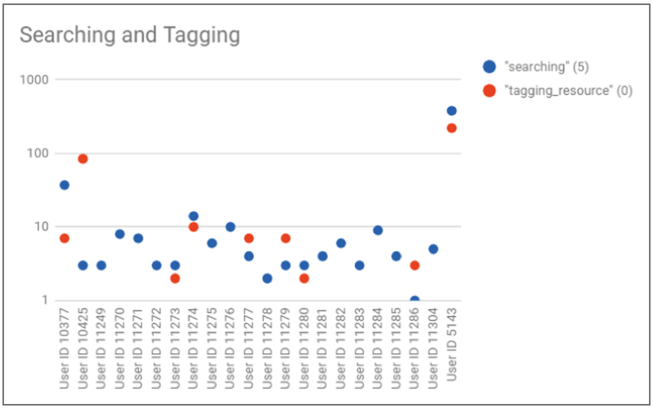

Fig. 7. Searching activities performed and resources tagged by users.

4 Conclusions

Investigating Knowledge-Intensive activities ("Search Term Selection", "Query Formulation", "Results Check" and "Information Extraction") helps visualize the behaviors involved in an exploratory search process and in describing how they relate to knowledge acquisition, sharing, storing and reusing. Taking as example the tagging resource activity presented in the log analyzed, it can be interpreted as a measure of user understanding or awareness about the subject searched. On the basis of Search as Learning concepts, it could indicate the occurrence of learning during the user's exploration of the retrieved results. Its frequency shows that users that perform more searching sessions tend to use tagging more often, as shown in Fig. 7. This observation could also indicate learning happening through interaction with contents during each search (i.e. texts read, diagrams analyzed, video watched).

In conclusion, from the application of the Exploratory Search Knowledge-intensive Process Model to log analysis, we were able to mind map search patterns and the learning process which are useful to identify four important characteristics of users' decision-making processes while searching online: **(1)** As seen in searching actions that prompted downloads without content checking, the decision criteria about which data are worth extracting is internalized and tacit as users get more acquainted with the subject by analyzing the information retrieved in each search. **(2)** As seen in the Term Criterion Label Sequence shown as example, there can be a refinement from general term (K1) to a specific one (K2), then a change of subject (K4) and the repetition of this pattern until users reach a decision to adopt a more specific subject not related to the general term previously used (K3). This means that users adopt different search profiles to draw inferences and devise shortcuts in order to improve their understanding. **(3)** The Term Criterion Label Sequence also helps to understand the formation and refinement of users' mental image about the subject and its impact on their decision process. The term refinement from general to specific, even a specification not related to the previous general term, indicates that as users acquire deeper awareness (possibly from analyzing the search results) their search intention is modified, as shown by a persistent change of subject. **(4)** As seen in the sample of an Exploratory Search KiP modeled for one of the sessions (Fig. 1), the purpose that drives the search turns into real search actions influenced by the selection of terms and their ensuing refinement.

A future development we foresee is the mapping of users' search pattern based on the keywords and terms used, to propose a Search Profile Taxonomy that could aid users improve the quality of their search (e.g. find the content that will better contribute to subject understanding). As for our ultimate goal presented in Sect. 1, a conceptual framework that can be used to identify some of the learning variables occurring during searches, the application of the Exploratory Search KiP Model to log analysis helped us visualize two possible metrics: (1) the balance between the challenges of the activity and the skills required to meet those challenges, and (2) the occurrence of tagging resources by users, and its contribution to revealing user understanding or awareness about the subject searched.

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References

1. Bates, M.J.: The design of browsing and berrypicking techniques for the online search interface. Online Rev. **13**(5), 407–424 (1989)
2. Bortoluzzi, M., Marenzi, I.: Web searches for learning: how language teachers search for online resources. Lingue e Linguaggi **23**, 21–36 (2017)
3. dos Santos França, J.B., Netto, J.M., do E. S. Carvalho, J., Santoro, F.M., Baião, F.A., Pimentel, M.: KIPO: the knowledge-intensive process ontology. Softw. Syst. Model. **14**, 1127–1157 (2015)
4. Marchionini, G.: Foundations for personal information infrastructures: information-seeking knowledge, skills, and attitudes. In: Information Seeking in Electronic Environments, Chap. 4, pp. 61–75. Cambridge University Press, New York (1995)
5. Netto, J.M., França, J.B.S., Baião, F.A., Santoro F.M.: A notation for knowledge-intensive processes. In: Conference Paper, June 2013

6. Netto, J.M., Santoro, F.M., Baião, F.A.: Evaluating KIPN for modeling KIP. In: Lohmann, N., Song, M., Wohed, P. (eds.) BPM 2013. LNBIP, vol. 171, pp. 549–561. Springer, Cham (2014). https://doi.org/10.1007/978-3-319-06257-0_44
7. Vakkari, P.: A theory of the task-based information retrieval process. J. Doc. **57**, 44–60 (2001)
8. Vakkari, P.: Exploratory searching as conceptual exploration. In: Proceedings of the Fourth Workshop on Human-Computer Interaction and Information Retrieval (2010)
9. Vakkari, P.: Searching as learning: a systematization based on literature. J. Inf. Sci. **42**(1), 7–18 (2016)
10. White, R.W., Roth, R.A.: Exploratory search: beyond the query-response paradigm. Synth. Lect. Inf. Concepts Retr. Serv. **1**(1), 1–98 (2009)
11. Wildemuth, B.M., Freund, L.: Assigning search tasks designed to elicit exploratory search behaviors. In: Proceedings of the Symposium on Human-Computer Interaction and Information Retrieval (2012)
12. Tibau, M., Siqueira, S.W.M., Nunes, B.P., Marenzi, I., Bortoluzzi, M.: Modeling exploratory search as a knowledge-intensive process. In: 2018 Proceedings of the 18th IEEE International Conference on Advanced Learning Technologies (ICALT 2018), Mumbai. IEEE, New York (2018)

Augmented Reality and Collaborative Learning

An Augmented Reality Framework for Gamified Learning

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Abstract. Formal education with physical objects is resource-intensive and does not scale well. In self-regulated settings, the long-term motivation of learners is an additional issue. Interactive 3D models provide a solution, as they can be replicated as needed. The user experience and immersiveness suffers in conventional Web-based viewers. The concept of mixed reality which encompasses both virtual and augmented reality creates new opportunities. In this article, we present a framework for mixed reality training that allows students to experience 3D models in an augmented reality environment. The resulting app runs on the Microsoft HoloLens and is suited for several settings like bedside teaching and workplace learning. User motivation and learning success are supported by a gamification strategy that rewards the successful completion of quizzes. We evaluated our framework with students of a medical university. Our open source software can be readily employed in various academic and industrial application areas.

Keywords: Mixed reality · Augmented reality · Gamification Learning · Microsoft HoloLens

1 Introduction

Traditional formal learning concepts include book illustrations and physical objects. While images alone cannot convey a vivid understanding of spatial structures, physical objects are restricted in access since they are fragile. Interactive Web-based learning environments allow students to see, transform and annotate 3D models in a computer-generated world. The term mixed reality encompasses the spectrum between the real world that is embedded in augmented reality (AR), and the purely virtual reality [7]. Mixed reality provides an interactive and effective way of learning where the student can freely explore virtual 3D objects from any view angle [15]. These objects are always available and cannot

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be damaged. They can be shared online to be viewed by many persons at different locations in parallel. Mixed reality is ideally suited for a wide variety of Web-based learning scenarios including problem-based learning and workplace learning. Bedside teaching is considered an ideal clinical teaching modality [10], where medical students examine patient conditions in the patient's room. Especially for human anatomy, a profound understanding of three-dimensional structures is essential. Since AR systems like the Microsoft HoloLens can display information by overlaying the view of the real world, students can combine the study of anatomical models with practical training procedures [5]. Concerning the pedagogical aspect, research indicates that learning anatomy with a 3D model can improve the student's test results [8]. Additionally, students can use the tool in self-regulated learning [14]. During the preparation phase, information like 3D models and quizzes are gathered. Within the learning phase, the new information can be used to enhance knowledge. In the reflection phase, badges show if the learning process was successful.

In this article we present *GaMR*, a gamified mixed reality framework which helps students to understand 3D structures, to keep motivated and to enhance the impression on the long-term memory. It is based on our previous work on a gamification framework that allows learning communities and individual learners to configure game elements and game rules in an intuitive, fine-granular and flexible way, without programming experience [6]. We applied the gamification framework and successfully evaluated its conceptual and technical applicability in a mixed reality context. Students can profit from game-based learning [11] by using quizzes and badges. The resulting collaborative learning application is available as an open source solution[1].

The paper is structured as follows. Section 2 discusses related work and technical backgrounds of the prototype. In Sect. 3 the conceptual design of the framework is elaborated. Section 4 describes details and challenges of the implementation. The evaluation of the framework is shown in Section 5 and Section 6 concludes the paper with an outlook on future work.

2 Background

In this section we discuss related work and introduce important technical concepts used in our implementation.

2.1 Related Work

Zygote Body [17] is a Web-based 3D viewer for human anatomy. The application offers schematic models of the male and female body where every part of the model is labeled with its English name and an excerpt from the part's Wikipedia article. Additionally, users can add their own annotations and gain access to more detailed models, e.g. of a dissected heart or an eye [17].

[1] https://github.com/rwth-acis/GaMR/.

Another interactive application is Anatomy Learning 3D Atlas [1]. It is available for Android smartphones and as a WebGL version for desktop browsers. Pre-made schematic 3D models show segments of the human anatomy.

The Case Western Reserve University presented Holoanatomy[2], a HoloLens application for visualizing anatomy. It features pre-defined annotations.

A Web-based viewer for 3D models is the Anatomy 2.0 application where users can add annotations [9]. Moreover, the application supports collaboration between learners because the annotations and the user's views can be synchronized. The project also allows authors to upload their own 3D models.

The GaMR framework builds on the concepts of these applications and improves them by adding gamification with the aim of increasing the user's long-term motivation and guide the learning process. Additionally, a comparison of the learning tools shows that all but Anatomy 2.0 work with pre-defined content like 3D models and quizzes. This restricts their use cases to the given fields of study. With the GaMR framework, custom 3D models, annotations and quizzes can be added in order to adapt it to the use in arbitrary courses. Moreover, most solutions are still limited to desktop applications. In contrast to this, models on the GaMR framework can be viewed on the HoloLens in mixed reality.

2.2 Gamification

While students can use the presented applications for learning, they do not support the student in long-term engagement. This can be achieved by the concept of gamification. Elements from games like quest systems, points, achievements or badges help to motivate and reward users for performing tasks [4]. This is realized by creating goals. This practice can give feedback about the task progress and when it is finished the rewards trigger a feeling of success.

In order to design gamification, one needs to understand the factors which improve motivation. The Octalysis framework defines eight drives which motivate humans [3]. One of them is *meaning* which states that people like to contribute to an important project with an ambitious aim. Another aspect is *accomplishment*. In the context of learning, students can be motivated by reviewing their progress and remembering their mastered challenges. Additionally, *empowerment* plays a role where the user is given creative freedom. With *ownership*, the students can gain badges which makes their success evident. *Social influence* as in competition but also cooperation can also trigger the interest in a project. Furthermore, *scarcity* motivates the students to continue the task to achieve goals which cannot be reached immediately. *Unpredictability* can also support the user's curiosity to go on exploring the application. The last factor is *avoidance* which means that the user tries to prevent failure and its consequences [3].

[2] https://www.microsoft.com/de-de/store/p/holoanatomy/9nblggh4ntd3.

2.3 Technical Background

The developed framework is executed on the Microsoft HoloLens which is a head-mounted display for mixed reality[3]. It continuously performs spatial scans of its environment to create a map of the surroundings. The device can locate its own position and react to user movements. Thus, virtual 3D models can be projected into the real world and stay fixed at their assigned position. This allows the user to walk around virtual objects, inspecting them from different angles similarly to the concept of holograms. Microsoft HoloLens is a standalone device which runs on the Windows 10 operating system. For the development, the 3D engine Unity was used which allows the creation of interactive 3D applications[4]. It provides support for different platforms and devices besides the HoloLens. The engine handles low level functionality like graphics rendering and simulations [16]. C# can be used to implement the application logic [12]. The implemented code is supported by Microsoft's MixedRealityToolkit[5]. This open-source project under MIT license is available on GitHub and contains different basic templates and scripts to speed up the development process in Unity. The gamification framework was developed at RWTH Aachen University [6]. It provides a RESTful API to administer the gamification of applications. Internally, this is realized by a PostgreSQL database. Furthermore, it can generate code for gamification elements and inject it into Web-based systems. The Gamification Framework administers the data as games, quests, actions, achievements and badges [6].

3 Concept

The GaMR framework is designed as a learning tool. Its structure can be seen in Fig. 1. Users can display custom 3D models and place them in the environment. Each model is instantiated with an annotation system which allows users to place markers on the object's surface and associate them with text or audio. Authors can create specials annotations sets based on the designated learning content and save them as quizzes. The student's task is to find the corresponding text to the given annotation marker or to match the marker to the text. The framework is gamified by badges and a progress bar to maintain the student's long-term motivation. Authors can define custom images and assign them to the badges. Each quiz contains one of these defined badges and it can be won by the student if all questions are answered correctly. The acquired badges can be exhibited to visualize the student's accomplishments. Additionally, a progress bar shows the amount of correctly answered questions in a quiz.

The gamification data of the quizzes are administered by the Web-based learning service [6]. Its interface is generally organized in games and quests which contain actions. The quests are also associated with the achievements which refer to badges. In order to communicate with the service, a mapping from the

[3] https://www.microsoft.com/de-de/hololens.
[4] https://unity3d.com/de.
[5] https://github.com/Microsoft/MixedRealityToolkit-Unity.

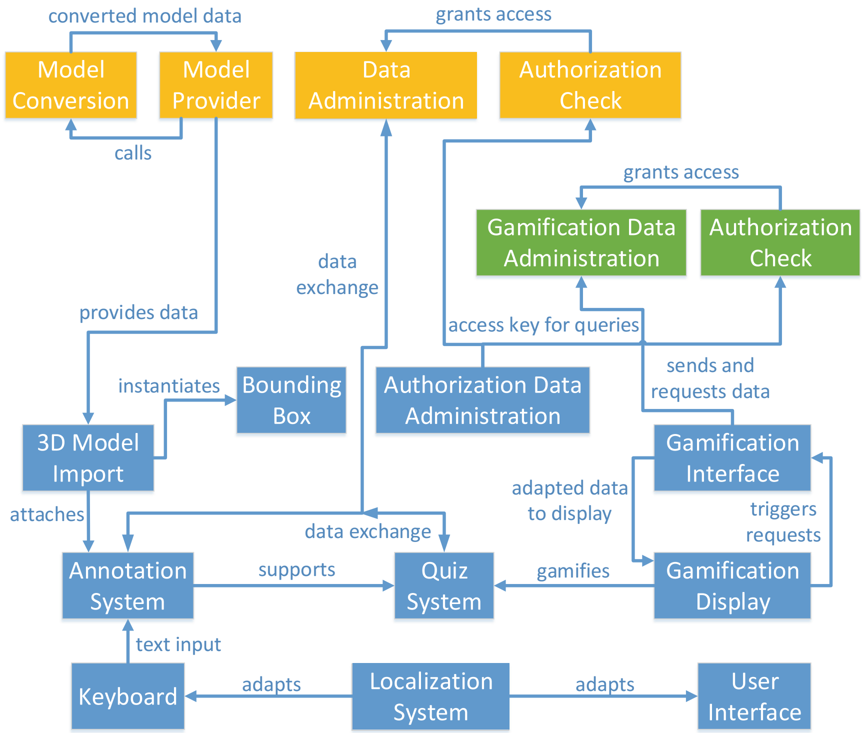


Fig. 1. Components and data flow of the developed system

components of the developed framework to the interface was designed. Similarly to the game which contains quests, the 3D model subjects contain quizzes. Thus, quizzes are regarded as quests. The individual questions of a quiz are mapped to actions of the quest. If a question is answered correctly, the corresponding action is triggered. This way, the quest is fulfilled iff all questions in the quiz are answered correctly. The badge is issued by the Web-based learning service and added to the user's account.

4 Implementation

Integrating a single sign-on authorization, processing the custom geometry, designing the user interface and adding the gamification elements were the challenges of the implementation.

4.1 Authorization

The developed framework uses the single sign-on protocol OpenID Connect which is supported by Google and Microsoft. This login process is required to secure the framework's data from unauthorized access. By handling the core functionality of the authorization and extending it with user identification [13], the protocol is suitable to solve this task. The challenge was to integrate the protocol's communication sequence into the HoloLens app as it usually requires a Web server. It was realized using custom URLs which guide the application flow from the login provider back to the HoloLens app.

4.2 3D Model Import

The framework uses 3D models from the existing repository of Anatomy 2.0 [9]. It mainly contains 3D scanned objects from the medical field such as a brain or skull. The objects are stored in the XML-based X3D file format [2].

Unity does not support the import of X3D files at runtime. However, an author should be able to add new models to the framework without re-compiling it. Thus, a custom solution was implemented. Its import process is displayed in Fig. 2. On the backend, the X3D file is parsed and the important information about the geometry like the vertex and face arrays is extracted. After this, they are packed into a JSON string which is offered to the frontend by the backend's RESTful service. This JSON string is also cached in order to optimize the performance for subsequent requests of the same 3D model.

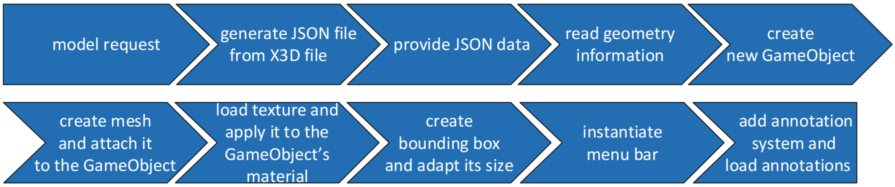


Fig. 2. Linear process diagram showing the steps to instantiate a 3D model

When a user loads a 3D model the frontend requests it at the RESTful service and it receives the JSON file. The contained information is used to construct the object's mesh which represents the object's surface. Unity can directly create meshes based on an array of vertex positions and a corresponding face array.

4.3 3D Transformation Widget

Users need to be able to move, rotate and scale the imported 3D models. Different transformations need to be realized without hiding the model under distracting controls. Graphical layout applications solve a similar two-dimensional problem by drawing a box around created elements; the developed three-dimensional solution is based on the same principle. Imported models are encapsulated in a tight-fitting wire-frame cube as depicted in Fig. 3. This bounding box contains

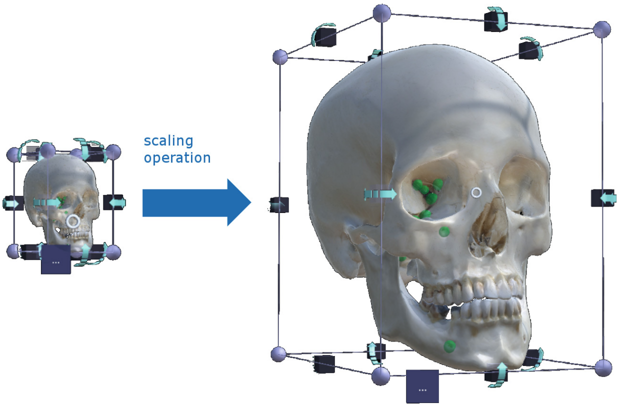
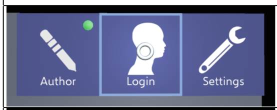
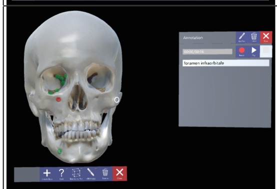


Fig. 3. Bounding box and its widgets for rotation and scaling

widgets for scaling and rotation at intuitive positions. For instance, the object can be scaled by dragging the corners of the cube. The 3D rotation also beared a challenge as a free 3D rotation is difficult to control with one gesture. Instead of that, the widgets were placed on the midpoints of the cube's edges and only allow rotation operations around one axis at a time.

Table 1. Overview of developed user interface widgets

Screenshot	Challenges
	**Button Widgets** • activated by gaze • custom captions • advanced animations for user awareness
	**3D Keyboard** • input field kept in sight • integration into the program flow • adapts to selected language
	**Annotation System** • placement of markers on the model's surface • stores user-defined text, e.g. to label a marked point or region on the model
	**Badges and Progress Bar** • the progress bar rises with the number of correctly answe-red questions • authors can create custom images for the badge

Widgets are kept at constant size so that they can be selected comfortably.

4.4 UI Widgets

The framework implements various solutions to user interface related problems which are listed with their challenges and features in Table 1.

4.5 Localization

The user interface is localized into the English, German and Dutch languages. The implemented manager loads the translations as a dictionary. It is granted that there will always be a meaningful translation displayed. The localization system also affects the keyboard as it adapts its layout to the chosen language.

5 Evaluation

The framework was evaluated at Maastricht University. Four lecturers and fourteen students from a medical degree program participated in the evaluation. Both groups created annotations on anatomical 3D models like the 3D scan of a skull or brain. The lecturers could use the author functionality to create quizzes and define badges. After that, the students answered the quizzes. Thirteen participants were not familiar with AR reality and did not know the HoloLens. They were enthusiastic about its possibilities and potential use cases for medical learning and training.

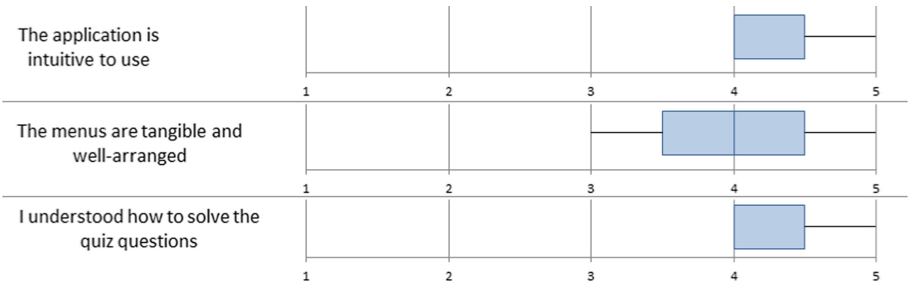


Fig. 4. Excerpt from the survey results

Figure 4 shows an excerpt from the questionnaire's result. The participants praised it as visually appealing and commended the intuitiveness of the menu design. The progress bar helped to gain an overview about their quiz results. Badges were perceived as motivating and encouraging to follow up the quizzes.

Furthermore, a technical evaluation was conducted to determine the framework's performance requirements. The framework was running on the HoloLens while the performance data were measured on Unity's profiler and the *Device*

Portal of the HoloLens. The results show that the framework runs at 30 frames per second with objects of 30,000 vertices. This standard value allows the human eye to perceive movements smoothly. More complex objects decrease the framerate until objects with one million vertices lead to a memory overflow on the HoloLens. The parsing times of the X3D files to JSON data for sending to the frontend have also been measured. It became evident that objects which run on usable framerates are converted in under one second. A 3D model with 30,000 vertices was converted in around 100 milliseconds on a standard office computer.

6 Conclusions and Future Work

Usually, students learn with physical objects and illustrations in textbooks. Apart from the fact that physical objects are fragile, they are also limited in access. Illustrations in textbooks sometimes do not convey a good impression of the full spatial extents of an object. These learning methods can now be improved by using mixed reality concepts. In this paper, the gamification framework for mixed reality training as a tool for learning 3D structures was introduced. Authors can create quizzes which are based on the annotation system and students have to assign the text of the annotation to the marker or vice versa. In order to maintain a long-term motivation, gamification elements where added to the framework. Students can win badges and a progress bar informs them about their successful learning progress.

Further development will extend the framework by new features. Implemented solutions like the authorization procedure and UI elements will be made available as separate toolkits and libraries. Developers can import them into their projects. The framework will be refined, e.g. by improving its framerate to 60 frames per second as soon as faster hardware is available.

The evaluation showed that the framework can be used in smaller courses. In future, the application will also run on desktop computers and virtual reality devices. As the GaMR framework is not restricted to an educational context, it is possible to be used in various other fields of applications. One example is a design or fabrication pipeline where designers are able to add their 3D models to the repository and can place the virtual prototype in the real environment. The annotations may be employed as bulletin boards to leave notes for others directly on the 3D object. Another use case is the deployment at a practical training scenario during apprenticeship. For instance at a workplace, schematic 3D models of tools or operating panels can be integrated. Instructors have the opportunity to add explanations and process steps to the 3D model as annotations. A trainee can overlay these schematic models over the real tools and be guided through the process based on the tool's operations.

As a conclusion, the GaMR framework provides a learning tool for versatile educational training scenarios.

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References

1. AnatomyLearning: Anatomy Learning (2017). http://anatomylearning.com/en/. Accessed Apr 2018
2. Brutzman, D., Daly, L.: X3D: Extensible 3D Graphics for Web Authors. Morgan Kaufmann, Burlington (2010)
3. Chou, Y.k.: Actionable Gamification. Beyond Points, Badges, and Leaderboards (2015)
4. Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From game design elements to gamefulness: defining "gamification". In: Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, pp. 9–15. ACM (2011)
5. Kamphuis, C., Barsom, E., Schijven, M., Christoph, N.: Augmented reality in medical education? Perspect. Med. Educ. **3**(4), 300–311 (2014)
6. Klamma, R., Arifin, M.A.: Gamification of web-based learning services. In: Xie, H., Popescu, E., Hancke, G., Fernández Manjón, B. (eds.) ICWL 2017. LNCS, vol. 10473, pp. 43–48. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-66733-1_5
7. Milgram, P., Kishino, F.: A taxonomy of mixed reality visual displays. IEICE Trans. Inf. Syst. **77**(12), 1321–1329 (1994)
8. Nicholson, D.T., Chalk, C., Funnell, W.R.J., Daniel, S.J.: Can virtual reality improve anatomy education? A randomised controlled study of a computer-generated three-dimensional anatomical ear model. Med. Educ. **40**(11), 1081–1087 (2006)
9. Nicolaescu, P., Toubekis, G., Klamma, R.: A microservice approach for near real-time collaborative 3D objects annotation on the web. In: Li, F.W.B., Klamma, R., Laanpere, M., Zhang, J., Manjón, B.F., Lau, R.W.H. (eds.) ICWL 2015. LNCS, vol. 9412, pp. 187–196. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-25515-6_17
10. Peters, M., ten Cate, O.: Bedside teaching in medical education: a literature review. Perspect. Med. Educ. **3**(2), 76–88 (2014)
11. Prensky, M.: Computer games and learning: digital game-based learning (2001)
12. Rogers, M.P.: Bringing unity to the classroom. J. Comput. Sci. Coll. **27**(5), 171–177 (2012)
13. Sakimura, N., Bradley, J., Jones, M., de Medeiros, B., Mortimore, C.: OpenID Connect Core 1.0 (2014)
14. Schunk, D.H., Zimmerman, B.J.: Self-regulated Learning: From Teaching to Self-Reflective Practice. Guilford Press, New York City (1998)
15. Trelease, R.B., Nieder, G.L.: Transforming clinical imaging and 3D data for virtual reality learning objects: HTML5 and mobile devices implementation. Anat. Sci. Educ. **6**(4), 263–270 (2013)
16. Westre, A.: Design Games for Architecture: Creating Digital Design Tools with Unity. Routledge, Abingdon (2013)
17. Zygote Media Group, Inc.: ZygoteBody (2017). https://www.zygotebody.com/. Accessed Apr 2018

A Collaborative STEM Project with Educational Mobile Robot on Escaping the Maze: Prototype Design and Evaluation

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Abstract. In Thailand, many students are bounded to the topic-oriented learning which does not well promote applying knowledge across subject domains. In recent years, STEM strategy has widely been accepted to induce the integration of important learning subjects; meanwhile, educational mobile robot project plays an increasing role to promote students to work collaboratively to construct their robots to achieve the goals. In addition, the project encourages students to learn, to think and to experience learning difficulties on a trial-and-error basis. Therefore, this study proposes a design of collaborative STEM project by using an educational robot to achieve the mission of escaping the maze. Project guidelines and robot specification are illustrated, while a robot racing field with learning challenges and an example robot model were developed. Moreover, a practice guide was designed to facilitate students' collaborative learning activities. With a simple experiment, the attitudes of experts on STEM, robotics, and project design were investigated. The findings of this study could be the ideas for improving the project before the implementation. Besides, other schools and universities could consider this work as a practical guideline to enhance students' foundation to develop innovations in the future.

Keywords: Educational mobile robot · STEM · Collaborative learning Project-based learning · Technology education

1 Introduction

In the past decades, technology and innovation have brought evolutions to the world. It turns many societies at all levels more convenient, productive and prosperous with a wide range of applications. Many research studies have agreed that the integration of various knowledge disciplines plays a crucial role in that success; meanwhile, the collaboration is essential to generate more possibilities [1, 2].

Owing to the present learning approach of many schools worldwide, students encounter the passive lecture, receive the paper-based practices, assignments, and exams. In other words, they are limited to apply their knowledge with the real-world

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applications and innovations, regardless of the real difficulties and challenges of the relevant contexts. Moreover, they are not encouraged to practice their capacity to develop the innovative foundation in collaboration with others [3].

In the past years, many studies have repeatedly shown that it is important for students to emerge themselves in this experience. Many integrated learning models have been curated to address these challenges. Among them, STEM has been widely accepted in promoting integrated learning from the primary schools to higher education. Requiring the knowledge of Science, Technology, Engineering, and Mathematics, STEM could encourage the students to develop innovation through its essential process including planning, thinking, problem-solving, and development [4, 5].

With the advancement of technology, the field of robotics has been applied in a wide range of applications from the personal scale to the industrial scale. It not only increases the productivity, reduces the errors, but also provides the conveniences and flexibilities to the users. In the meantime, many educational robots have been developed for these purposes since they are affordable, portable and understandable [6–8]. It requires a short learning time to manipulate the robots embedded with some technologies in corresponding with the programmed instructions for certain goals. Besides, the educational robots are the perfect tools to facilitate active learning activities.

Based on this particular perspective, this study proposed a STEM project design by incorporating with the educational mobile robot. A learning scenario of escaping the maze has been used as it provides different learning challenges and difficulties to study; in addition, this scenario is widely adopted in various industrial applications. In the learning process, students with their teammates are encouraged to think, analyze and solve many obstacles collaboratively by integrating the understanding of multiple subjects to make their robots exit the maze efficiently. This paper mainly presents the design and prototype of the proposed project; accordingly, the experts were invited to reflect their attitudes towards this proposal on different dimensions. The findings of this research shed the light of concrete foundation to improve this project design before the implementation. Hence, this study is directed with two research questions:

(1) What is the prototype design of collaborative STEM project with educational mobile robot on escaping the maze?
(2) What are the attitudes and feedbacks of the experts towards the proposed project design?

2 Related Study

2.1 Stem

In the 21st-century education, STEM has been well accepted for multidisciplinary studies among Science, Technology, Engineering and Mathematics [9]. It aims at promoting students to inquire and construct knowledge collaboratively [10]. Its essential mechanism is to encourage the flow of learning integration what students have learned in the class with the real-world confronting problems [11]. With this process, students are required to analyze, apply and create the solution or product, known as project-based learning. In the meantime, students inquire the knowledge by trial-and-error basis.

In the past years, there are many studies on STEM on various aspects. For example, Pardo proposed a game to promote moral mechanics based on STEM approach [12]. The findings showed that the students could make analysis and decision appropriately which would affect the moral decision making. Yanchinda et al. integrated STEM with Fuzzy machine for the farmers for agricultural development and sustainability [13]. Furthermore, STEM was adopted for mobile robot class with high-school students, which result in the increasing rate of students admission in Engineering field [14].

Therefore, this study would employ the advantages of STEM concept with the proposed project design to promote collaborative learning with educational mobile robot.

2.2 Educational Mobile Robot

Robotics technology has improved continuously. Robots have been applied in our daily lives on broad applications, which can be categorized as fixed robot and mobile robot. In education, robots have been adopted as a learning tool which they could give more challenges than the traditional learning of lecture and simple assignment. Moreover, the educational robots also increase learning motivation as they could provide interaction with exciting visualization [15].

Robots have been used in the learning context in two mechanics. One for general purpose of robotics learning, while the other one for promoting learning, critical thinking, problem-solving and teamwork [16]. Alves et al. urged that robots give individual students learning by doing for different levels of learning performance. In the past decade, many researchers have applied educational robots differently [7]. For example, Khamphroo et al. proposed a jigsaw puzzle method to control the robot, which could help the students to learn programming effectively in minutes [17]. In addition, mobile educational robots have been used in teaching AI since they come with many sensors for educational purpose at an affordable price [8].

Based on this perspective, this research incorporated the educational mobile robot with the proposed project design to promote learning motivation in solving the real situation.

3 Collaborative STEM Project Design

3.1 Project Design

Overview. This project used educational mobile robot kit as a learning tool to integrate the knowledge of Science, Technology, Engineering and Mathematics (STEM) in order to achieve the goal of escaping the maze, as shown in Fig. 1. The students learn to

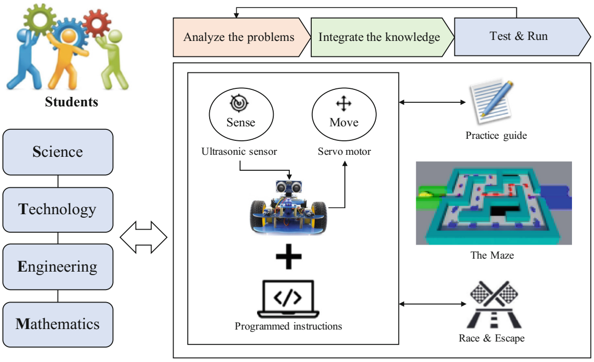


Fig. 1. Overall structure of collaborative STEM project

assemble the robot and program it to run. Based on students' programmed instructions, the robot detects the route and obstacles through the ultrasonic sensor; in the meantime, gearing the motor for preferred speed and direction for certain situation. Moreover, the robot and instructions need to be adjusted for different challenges inside the maze.

There are two main sessions in this project to help students to learn meaningfully. In addition, collaborative learning was adopted for this project as it plays an essential role in promoting students to learn, think and work collaboratively by following the designed practice guide. Moreover, this project can be applied in a regular classroom setting in high school or university for 2–3 weeks, run as a workshop for one to two days, managed as a special program for team building or incubating the innovative ideas.

Project Setting and Rules. This project was designed with suggested group members of 3–4 students for collaboration purpose. Each student should be familiar with basic electronics, e.g., basic knowledge of electronic components, how to connect, and basic computer programming, e.g., syntax, data structure, and algorithms. The goal of this project requires each team to assemble and manipulate their educational mobile robot to escape the maze by applying knowledge of Science, Technology, Engineering, and Mathematics with peers. The project can be separated into two main sessions.

Learn and Practice. This session aims to get students familiar with the robot kit and the maze, which may take around 3–4 h at least depending on the background of the students. Each team is encouraged to assemble and program their robot by following the instructions on a collaborative worksheet. In the meantime, they can test their robot with the maze to learn how to adapt their robot to pass the challenges in order to escape. This process requires them to analyze the upfront problems and try to solve them with integrated knowledge of STEM. Meanwhile, they have to run and test their robot if it works with that particular situation; otherwise, analyze again. Moreover, the teacher can take this opportunity to observe their learning process and give the consultation appropriately, as a facilitator.

Race and Escape. This session is exciting. Each team becomes the contestants of the robot racing with other teams to escape the maze without teacher's consultation. Each team's robot is expected to escape the maze with the maximum time of 15 min, while the robot spending minimum time is the winner. During the race, each team has not only to control their robot successfully but also to retune and refine their robot and programmed instructions for the best result with the shortest time. Unlike the practice in the previous session, each team in the race would encounter new problems and new challenges when speeding up their robot. These difficulties may include the pressure of time constraint and team arguments; hence collaboration even matters. However, the teacher may adjust the racing time and qualified time upon the upfront situation.

3.2 Description of Robot and the Maze

Educational Mobile Robot. In this project, an educational mobile robot kit from Waveshare, namely AlphaBot, is prepared for each team. This kit is affordable and portable for students to practice in a variety way of learning. As shown in Fig. 2 (left), it comes with a wide range of robot parts, including body structure (mainboard, chassis, acrylic sheets), sensors (tracker, image interrupter, IR proximity, ultrasonic), driving (motor with gearbox, servo, wheels, Omni-direction wheel), and micro controller (Arduino UNO Plus). As shown in Fig. 2 (right), the robot's total height, width, and length are 12, 17 and 20 cm, respectively. Note that the kit also supports Raspberry Pi.

Fig. 2. Robot parts (left), the robot (right)

There are two main factors that lead to the success of the robot. First, the assembly process which might include the position and the fixation of driving parts, sensors, components, etc. Second, the programmed instructions. This plays an essential role in controlling the robot as different instructions lead to the different result of robot performance. In this project, C language is used to program Arduino's microcontroller. For better understanding, sample code snippets of different robot functions are shown in Fig. 3, while the **bold** texts contrast the code differences.

```
Serial.begin(115200);
pinMode(IR, INPUT);
ArduinoCar.SetSpeed(250);
```

```
Serial.begin(115200);
pinMode(IR, INPUT);
ArduinoCar.SetSpeed(50);
```

(a) Different robot speed – fast (left), slow (right) could affect immediate stop

```
Fdistance = Fdistance/58;
void Distance_display() {
  if((2<Distance)&(Distance<400)){
    Serial.print("Distance:");
    Serial.print(Distance);
    Serial.print("cm\n\n");
 } else Serial.print("!!! Out of range\n");
  delay(250);
```

```
Fdistance = Fdistance/20;
void Distance_display() {
  if((2<Distance)&(Distance<400)){
    Serial.print("Distance:");
    Serial.print(Distance);
    Serial.print("cm\n\n");
 } else Serial.print("!!! Out of range\n");
  delay(250);
```

(b) Different sensing frequency – high (left), low (right) could affect the processing resource

```
if(Distance < 40)
    while(Distance < 40){
      Car1.Right();
      Distance_test();
      Distance_display();
    } else Car1.Forward();
```

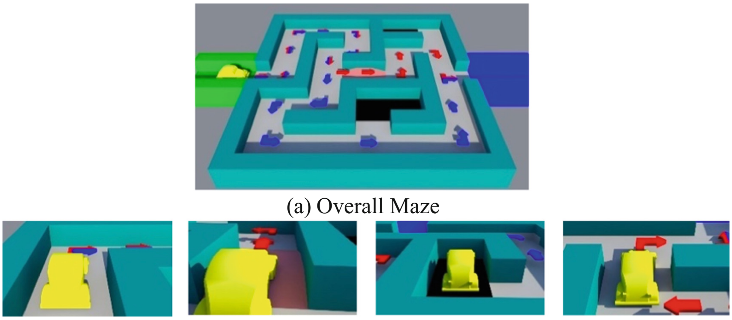
```
if(Distance < 10)
    while(Distance < 10){
      Car1.Right();
      Distance_test();
      Distance_display();
    } else Car1.Forward();
```

(c) Different sensing distance – long (left), short (right) could affect accuracy

Fig. 3. Sample code instructions to program the robot

The Maze and Challenges. The maze layout, as illustrated in Fig. 4(a), has one entrance (green) and one exit (blue). It comes with the total area of 1.2 × 2.4 m with 20 cm high and the track of 30 cm wide. The suggested condition of the maze would be wood, which is affordable and good for customization. With this surface, the maze can provide optimal friction for the robot, also serve as a good reflector to the ultrasonic wave. Moreover, it can help absorb the force when robot collides with the maze.

The maze was designed for two possible routes (either red or blue arrows) with 12 turns (either left or right), two-ended blocks (black shaded) and one short-elevation (20-degree slope angle in 15 cm length, 10 cm high). The maze wall can be detected with a range of the ultrasonic sensor on the AlphaBot. To overcome these difficulties, the robot needs to work with two considerations of ultrasonic sensor (to sense the



(a) Overall Maze

(b) Turning right (c) Encountering the elevation (d) Encountering the ended-block (e) Considering to turn right

Fig. 4. The maze and challenges (Color figure online)

obstacles) and servo motor (to adjust the movement) simultaneously according to the position of the robot in the maze. In other words, the decision of robot is made upon what it is encountering. Moreover, all the decisions robot made are done in respect of the programmed instructions. The challenges of the maze are described as follows.

The simplest challenge in this maze is when the robot meets the turn. As shown in Fig. 4(b), the robot is about to turn right. This challenge requires the students to sense the obstacle walls if right turn or left turn is required; correspondingly, the direction and speed of the robot have to be calculated in order to turn the robot appropriately. The next challenge is short elevation, as shown in Fig. 4(c). Regardless of turning the robot, it requires adjusting the robot's speed for smooth running up and down while maintaining itself on the track. To avoid this challenge is suggested, the ended-block, as shown in Fig. 4(d). Probably the most difficult challenge in the maze, it requires moving back and forth appropriately while searching for the exit and recalculate the speed of wheel's motor to turn the robot until the route is clear. As shown in Fig. 4(e), the robot faces the two-way junction. It requires making consideration of the correct turn in reaching the maze exit; otherwise, the robot may face the wrong route and require more time to escape. All of these challenges are inter-operational and functional since the result of current instruction, and robot position/direction would affect the starting point of following instructions.

3.3 Collaborative Learning Activity

In this project, students in each team are encouraged to work collaboratively. To facilitate this, each team is guided with the practice guide comprising of two parts: robot assembly and robot programming. As shown in Fig. 5, the developed guideline applied a guided-inquiry learning process. Some instructions are given, while the rest is for team analysis, discussion, and thinking.

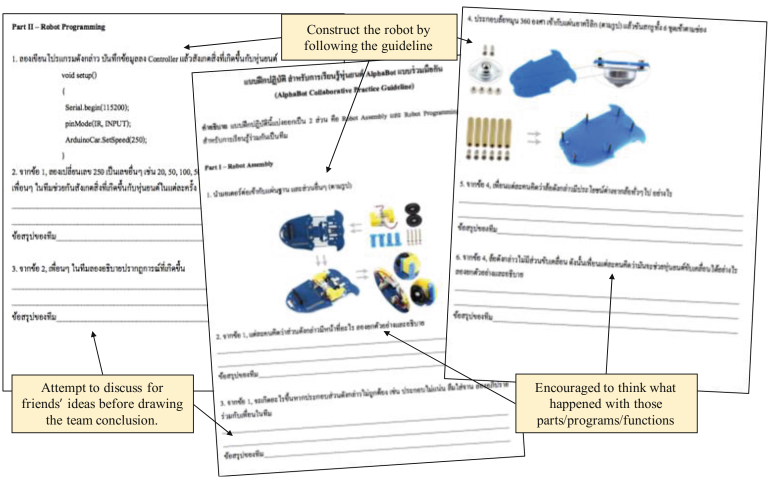


Fig. 5. Illustrations of collaborative practice guideline

For example, the middle and the right pages are part of Robot Assembly. The students are guided to assemble the parts following the guide, then asked to think about those functions in relevant to the robot. Moreover, they are encouraged to discuss in the team for different ideas/opinions before drawing the team conclusion. The left page is part of Robot Program. The students are prompted with a code snippet to test with their robot; meanwhile, they observe what happened with the robot. In addition, they are encouraged to alter some values and test for different results. Consequently, they are required to discuss the scientific phenomena with peers.

4 Evaluation

4.1 Method

To evaluate the effectiveness of the proposed collaborative STEM project design, an evaluation of experts' attitude on following dimensions has been investigated with a simple experiment: robotics (RBT), project design (PRJ) and STEM (STM). A total number of 23 independent experts were invited in this study (Male = 17, Female = 6), each has at least one year of experience on the related dimension with higher education background. Most of the experts work in academia as lectures and technicians, while the rest work for company.

In this study, a questionnaire used to collect the attitudes was adapted for the context of this study with a total of 15 five-point Likert Scale items (RBT = 5, PRJ = 5, STM = 5) [5, 18–20], while the internal consistency was at an acceptable reliability (Cronbach's $\alpha = 0.82$). Moreover, the open-ended questions were attached to the end of each dimension to collect the qualitative feedback and comment towards such areas, after a cross validation by the authors.

4.2 Result

Based on the experts' responses on the questionnaire, it was found that the experts rated their attitudes on the proposed project design on medium and low levels on RBT ($M = 3.38$, $SD = 1.04$), PRJ ($M = 3.58$, $SD = 0.92$) and STM ($M = 2.96$, $SD = 1.04$), as shown in Table 1. By considering the difference of gender effects on the attitudes, it was shown that male and female experts revealed no much difference. This result can be implied that the proposed collaborative STEM project design need to be improved on all dimensions.

Table 1. Results of experts' attitudes on different areas.

Dimension	Attitude ($M \pm SD$)			
	Male ($n = 17$)	Female ($n = 6$)	Sum ($n = 23$)	Interpretation
RBT	3.35 ± 1.03	3.42 ± 1.05	3.38 ± 1.04	Medium
PRJ	3.61 ± 0.92	3.56 ± 0.91	3.58 ± 0.92	Medium
STM	2.97 ± 1.04	2.95 ± 1.05	2.96 ± 1.04	Low

To better understand these phenomena, the qualitative results from the experts are presented in Table 2 on each considered dimension. This data was analyzed by the authors individually before reaching for the final results by the means of discussion. Note that the following +, – and * signs are used to represent positive feedback, negative feedback and suggestion, respectively.

Table 2. Results of experts' qualitative feedbacks.

Dimension	Qualitative responses
RBT	+ Promote systematic thinking and creativity with logics to solve problems
	+ Give hands-on experience of robotics, programming and logic design
	* It can be applied to help the vehicle without a driver
PRJ	+ Students can apply many ways and can learn from the real work
	+ Children have the opportunity to use the ideas, analysis and development of the necessary skills
	+ The advantage of this experiment is the learner will have creative thinking and creative solutions
	* Can be developed in other subjects, e.g. planning and management etc.
	* This project can be applied in computer programming by giving students a challenge to control the robot with more complex decision; on the other hand, it can be used in data analytics, mobile app development
	* Can work with the calculation about value of each part of the work
STEM	- This experiment is not suitable for all groups, each may use different tools
	- It should be clear what the model focuses on and how it is measured
	+ Student can use knowledge in many fields to solve the problem and students can learn theory from the actual situation
	* Can be integrated with Maths and Physics in the topic of distance, speed, movement, speed of sound in the air
	* Add details of collaboration in the project. Increased ability to measure aptitude and division. Be clear about job details and goals
	* The experiment should have pre-test and post-test
	* Should increase the dimension of the problem or step of application

In addition, we have found that the experts showed the positive relationship of their attitudes on STM and RBT ($r = 0.60$), and STM and PRJ ($r = 0.46$), see Table 3. This indicated that their attitudes and feedbacks have perspectives on the relevance of STEM and robotics on the proposed project.

Table 3. Pearson's correlation coefficient among dimensions of experts' attitudes.

Dimension	RBT	PRJ	STM
RBT	1	–	–
PRJ	0.09	1	–
STM	0.60	0.46	1

The results of this evaluation, regarded as a preliminary result, will be seriously considered for improving the project design prior to the actual development in the next phase of this research study.

5 Conclusion and Discussion

This study proposes a collaborative STEM project design with educational mobile robot. The maze has been designed to generate learning challenges and missions. A detailed description of project structure, setting and rule have been presented, while robot specification and the maze layout have been visualized accordingly. The aim of this project is to strengthen students' foundation to think and work systematically by applying knowledge across disciplines. Moreover, a collaborative guideline has been developed to enhance students to work collaboratively during learning process of this project.

Based on the results of experts' attitude, this project was found with several limitations. For example, the current learning model could not facilitate all groups of students as they might need different tools. This maze could be adaptable to support more challenges. All of the gathered feedbacks and suggestions will be considered. In summary, the findings of this study could serve as a preliminary study for not only improve the project better but also shed light the opportunity in extending this project further.

As this project is at a very beginning stage, the authors seek to extend its value on several opportunities. First, the generalized model based on this project can be developed to serve the direction of the country of Thailand 4.0. Second, it is possible to integrate the ideas of this project with other Computer and Information Technology courses in order to tackle more industrial problems and applications. Finally, it could be meaningful if the learning process of all students have been valued, while their necessary soft skills have been promoted accordingly.

References

1. Entwistle, N.: Learning outcomes and ways of thinking across contrasting disciplines and settings in higher education. Curric. J. **16**, 67–82 (2005)
2. Levine, L.E., Fallahi, C.R., Nicoll-Senft, J.M., et al.: Creating significant learning experiences across disciplines. Coll. Teach. **56**, 247–254 (2008)
3. Duran, M., Höft, M., Medjahed, B., Lawson, D.B., Orady, E.A. (eds.): STEM Learning. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-26179-9
4. National Academy of Sciences: STEM Integration in K-12 Education: Status, Prospects, and an Agenda for Research (2014)
5. Tseng, K.H., Chang, C.C., Lou, S.J., Chen, W.P.: Attitudes towards science, technology, engineering and mathematics (STEM) in a project-based learning (PjBL) environment. Int. J. Technol. Des. Educ. **23**, 87–102 (2013)
6. Kopcha, T.J., McGregor, J., Shin, S., et al.: Developing an integrative STEM curriculum for robotics education through educational design research. J. Form. Des. Learn. **1**, 31–44 (2017)

7. Alves, S.F.R., Filho, H.F., Pegoraro, R., et al.: Proposal of educational environments with mobile robots. In: IEEE Conference on Robotics, Automation and Mechatronics, RAM – Proceedings, pp. 264–269 (2011)
8. Golestan, S., Taheri, K., Farahnak, M.R., et al.: Introducing i-puck: an educational mobile robot. In: 4th RSI International Conference on Robotics and Mechatronics, ICRoM 2016, pp. 607–612 (2017)
9. Weaver, G.C., Cook, D.D., Foster, C.J., Moon, S.M., Phegley, P.J., Tormoehlen, R.L.: Attracting Students to STEM Careers: A White Paper Submitted to the 2007–2013. Purdue University Strategic Planning Steering Committee pp. 1–15 (2007)
10. Yanchinda, J., Dahal, K., Sinthamrongruk, T.: STEM learning concept with fuzzy inference for organic rice farming knowledge acquisition. In: 2017 11th International Conference on Software, Knowledge, Information Management and Applications, pp. 1–8 (2017)
11. Wong, G.K.W.: Integrative learning in K-12 STEM education: how to prepare the first step? In: 2017 IEEE 6th International Conference on Teaching, Assessment, Learning for Engineering, pp. 80–87 (2017)
12. Pardo, A.M.S.: Computational thinking between philosophy and STEM. Programming decision making applied to the behaviour of "moral machines". In: Ethical Values Classroom. IEEE Revista Iberoamericana de Tecnologias del Aprendizaje (2018)
13. Yanchinda, J., Sinthamrongruk, T., Dahal, K.: STEM learning concept with fuzzy inference for organic rice farming knowledge acquisition. In: 2017 11th International Conference on Software, Knowledge, Information Management and Applications (SKIMA), pp. 1–8 (2017)
14. Tay, T.T., Lim, Z.Z., Chua, Y.L.: Utilizing autonomous mobile robot to increase interest in STEM. In: 2017 3rd International Conference on Science in Information Technology (ICSITech), pp. 161–165 (2017)
15. Avanzato, R.: Mobile robotics for freshman design, research, and high school outreach. In: IEEE International Conference on Systems, Man, and Cybernetics, pp. 736–738. IEEE, Nashville (2000)
16. Afari, E., Khine, M.S.: Robotics as an educational tool: impact of lego mindstorms. Int. J. Inf. Educ. Technol. **7**, 437–442 (2017)
17. Khamphroo, M., Kwankeo, N., Kaemarungsi, K., Fukawa, K.: MicroPython-based educational mobile robot for computer coding learning. In: 2017 8th International Conference on Information and Communication Technology for Embedded Systems (2017)
18. Gomez-de-Gabriel, J.M., Mandow, A., Fernandez-Lozano, J., Garcia-Cerezo, A.J.: Using LEGO NXT mobile robots with LabVIEW for undergraduate courses on mechatronics. IEEE Trans. Educ. **54**, 41–47 (2011)
19. Mioduser, D., Betzer, N.: The contribution of project-based-learning to high-achievers' acquisition of technological knowledge and skills. Int. J. Technol. Des. Educ. **18**, 59–77 (2008)
20. Turgut, H.: Prospective Science Teachers' Conceptualizations about Project Based Learning. Online Submiss. **1**, 61–79 (2008)

Collaborative Non-linear Storytelling Around 3D Objects

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Abstract. In informal learning settings, storytelling is a mean towards acquiring and sharing knowledge. On the Web, user generated content and digital representations of real-world artifacts contribute to the story's expressiveness. 3D objects are a good example of such representations, as they capture and distribute rich and complex information. We present an approach for the collaborative creation of non-linear stories in near real-time, centered around 3D objects. We use a metamodel, which acts as a basis for collaborative story creation. Stories are directly linked to 3D objects being attached to camera views and perspectives on a certain object. We instantiate story viewers from the collaboratively authored stories and use text and multimedia to annotate and browse the 3D objects. Our conducted evaluation proves the feasibility of the approach and promises good results in applying collaborative storytelling for 3D object browsing in order to scaffold informal learning.

Keywords: Non-linear storytelling · 3D object annotation
Collaboration

1 Introduction

Storytelling is a well-approved method for conveying knowledge, a way to make diverse information cohere [2]. A plot helps maintaining the listener's attention and facilitate learning by creating interconnections between the content [1]. Furthermore, storytelling is an interactive process, during which the participants as part of a *Community of Practice* (CoP) [14] collaboratively shape the story. Especially in many informal learning scenarios, enabling the collaborative creation of stories facilitates participation and knowledge negotiation [8]. Finally, through these collaborations, it is possible to identify the community's ignorance, which leads to a culture of evolution through collaboration, one of the fundamental principles of CoPs.

Many good examples for educational storytelling include the listener expecting a story and being told lessons along the way. However, in scenarios dedicated to knowledge transfer, there might be people wanting information, but being told

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a story. In this case, especially if the plot is dominant, but poorly authored, storytelling might be perceived as an unnecessary nuisance. A solution for this is delivering *non-linear stories*, as story consumers influence the direction of the narrative with their actions and creators have access to a richer mean of expressing their narration. Allowing the creation of non-linear stories provides a larger degree of freedom for both the authors and consumers. But this freedom comes at the cost of an increased complexity in creating the story. *Movement Oriented Design* (MOD) [12] is an approach assisting non-linear storytellers in wrapping up subject matter into compelling stories. A story is seen as a collection of *Story Units*, where each *Story Unit* has three components called *Begin*, *Middle* and *End* (BME). The *Begin* of a *Story Unit* is meant to "hook" the consumer. The *Middle* carries the main information, and the *End* either terminates the story or links it to the next *Story Unit*. This reduces the nature of a story to the arc of suspense in a concluded *Story Unit*. By enforcing this BME-scheme, authors are nudged into regarding a basic narrative structure, while having no upper limit on dramatic intensity. Using multimedia artifacts in digital non-linear storytelling bears the potential to improve conveying story content and offer a richer experience, beyond simple text [11]. Thereby a lot of hidden, non-obvious information contained within multimedia artifacts can be enriched using annotations that highlight the most important, interesting facts. Recently, transforming real-world artifacts into a digital format has become easier and more cost effective, enabling access to a huge pool of potential users. Moreover, using modern Web technologies, it is now possible to display the resulting 3D models directly in Web browsers. An example is given by 3D digital representations of real-world objects that are otherwise not reachable for the majority of learners, due to their perishable or expensive nature.

In this paper, we present a Web-based digital storytelling approach, which is used to create and share multimedia-based, non-linear stories around 3D objects in a collaborative manner. Therefore, we developed a well-defined metamodel according to which communities can collaboratively instantiate model-based stories in near real-time. The focus of these stories is placed on informal learning, which is meant to be supported through the mixture between collaboration in the creation process, annotation of 3D object views and camera perspectives with various multimedia such as text, videos and images and novel, intuitive consumption of the resulting non-linear stories. We have evaluated and implemented our concept using a near real-time collaborative prototype, and our findings demonstrate that this blending of concepts is well perceived.

2 Related Work

MOD is based on insights about plot structuring that date back to Aristotle [5], incorporating *Freytag's Triangle* [4]. This provides a convenient workflow of scaffolding the story in an incremental fashion. An example of a non-linear implementation of MOD is given in *Media Integrated Story-Telling* (MIST) [13]. Here, the authors solve the problem with the ambiguous affiliation of multiple *BME* components by not allowing the recursive split of a *BME* component directly. Instead, if e.g. a *Begin* should be further split into a *Begin*, *Middle* and *End*, those have to be combined under a new *Story Unit*, which is then associated with the initial *Begin*. The problem of unambiguous story paths is solved by forcing the author to define all transitions manually. The connections have to be drawn in a way, that each possible path through the story would result in a correct linear MOD story. *YouTell* [3] is a storytelling system that transfers the features of *MIST* to the Web and supplements them with a management interface, providing search functionalities and social features like story rating and expert-finding. Liu et al. [7] compare the effects of non-linear storytelling and linear storytelling by applying it as a Web 2.0 application of an animated picture book to third graders. They measure a steeper learning curve and higher engagement for the non-linear approach.

Recently, also commercial software companies are engaging more and more in creating tools that facilitate storytelling. *Adobe Slate* is a tool for assembling digital photos into linear photo stories for the Web. *Twine* is an open-source tool for creating and sharing interactive, non-linear stories in a text adventure like fashion. Their storyboard graphs allow for flexible plot design. Especially social media platforms also increase their focus on storytelling. *Snapchat* enabled sharing of linear autobiographic stories early on, a feature which lately has been integrated into *Facebook* and *WhatsApp* as well. With *Custom Stories*, *Snapchat* is currently trying to establish a new focus on collaborative storytelling.

Using dynamic 3D objects for teaching has benefits in terms of vividness compared to static photos. It can also be argued that similar to mnemonics, like the *Method of Loci* [10], learning with 3D objects can be beneficial by engaging spatial memory. Using 3D scanning techniques, rare, fragile or immobile objects can be archived and made accessible for everyone. *Anatomy 2.0* [9] is a Personal Learning Environment (PLE) for the collaborative exploration and annotation of 3D objects for the Web. Users can tag objects in near real-time and gather in online course rooms in which the presentation of the object is guided by a teacher. Especially in the domain of cultural heritage, virtual museums are a large research area (e.g. [6]). Among others, the *Virtual Museum* by *VR3D* is a freely walkable virtual museum on the Web, which focuses on ancient Vietnamese relics. It provides explanations and stories around the models, synced with an automatic camera guidance system.

3 Use Case

For describing our approach, we consider two scenarios, story consumption and story creation, to showcase the requirements and exemplify its contributions.

Story Consumption. To consume a story, the user enters the *Story Consumer View* via her Web browser, chooses a 3D object and selects an attached story. After the story is loaded, she starts her journey through it. The stories are split into units, each unit corresponding to a story page and to a specific view on the 3D object. After each story page, there is either a single transition to the next page, or a decision between multiple possible steps, from which consumers select one, thereby experiencing different story paths. While clicking through the story pages, the camera automatically moves around the 3D object, focusing on different parts of it according to the story content. Besides these automatic camera movements, the consumer is free to also move the camera manually to have a closer look at certain aspects of interest. The connection between the current point in the story and the 3D object is marked with visual tags appearing on the object. By clicking them, consumers can get detailed information on specific features using text, images, links to external Web pages and videos. When the consumer reaches one of the possibly multiple endings of the story, she has the possibility to revisit certain parts of the story by using a go-back functionality to experience an alternative path at a fork encountered in previous story pages.

Story Creation. The user is an expert on a certain object and she has access to a digitized 3D version of it. In the *Story Consumer View*, she chooses to create a new story, which directs her to the *Story Editor View*. First, she connects the 3D model with the newly created story. Then, she starts to scaffold her story by first modeling the coarse structure according to MOD, without adding media content yet. She notices some lack of knowledge about a certain aspect of the object and asks another expert for help. The expert joins the *Story Editor View* and after a brief introduction (either via the chat provided by the editor itself or third party communication tools) he starts building his sub-story. The users start adding their multimedia content to the story graph and extending it, all in near real-time on the Web. They place tags on certain places on the 3D object to highlight those, and connect the tags with appropriate story sections. They also define camera settings to highlight relevant aspects of the object. Once the story is in a presentation-ready state, the users publish it, so it can be consumed by other members of the learning community. If later on, at any time a community member discovers a part of the story she can contribute to, it is possible for her to switch back to editing the story and add either additional content or even sub-stories connected to the overall plot to enhance it with new information.

4 Metamodel for Non-linear MOD Around 3D Objects

We created a metamodel (cf. Fig. 1) that can specify non-linear stories for 3D objects and connections between these 3D objects and media, tags and 3D properties such as position, camera angle and perspective. Due to its suitability for Web 2.0 collaborative storytelling, we choose to reflect the non-linearity using the interpretation of MOD from the MIST approach presented in Sect. 2.

The central entity of our metamodel is the *Story Unit*. A *Story Unit* has to have exactly one *Begin*, *Middle* and *End*, which derive from a *Movement*. All *Movements* have a title and the option for the author to leave a note. The recursive splitting of a *Movement* into further *Begin*, *Middle* and *End* is achieved by associating another *Story Unit* with the *Movement*, which is then split up. The *Media Object*s contain the actual media content presented to the consumer.

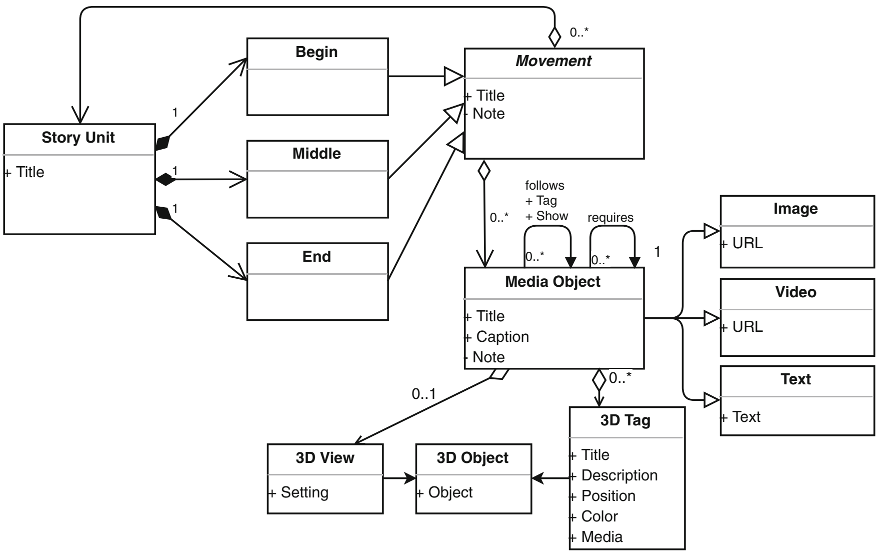

Fig. 1. Metamodel for non-linear MOD around 3D objects

It is an abstract entity with a title, a caption and again a note, from which the concrete entities *Image*, *Video* and *Text* derive. They constitute the media nodes, that the author will utilize. For dictating the story's flow, there is the *follows* relation between *Media Objects*. Each *Media Object* can have an arbitrary number of successors. These *follows* relations can have a tag and an option to only use the tag-clicking way to trigger the transition. Each *Media Object* can be associated with an arbitrary number of *3D Tags*. A *3D Tag* has a title, a description, a position, a color and a reference to a remote media file as attribute media. Each *Media Object* can also have at most one *3D View*, whose only attribute is the camera setting. From a conceptual point of view, it is also necessary to be able to associate the *3D Tags* and *3D Views* with the *3D Object* they belong to. As an experimental feature on top of the MIST layout, we introduce *Requirements* (called *requires* in the metamodel). Their purpose is to enable the story author to save some redundancy in the story graphs. If two nodes A and B are connected as $ARequiresB$, then while consuming the story, B will only be accessibly, if the viewer has already visited node A. This reduces the complexity of story setups, where two paths lead to the same or very similar states, which however result in a different progress of the story.

5 Realization

We implemented our concept using state-of-the-art frontend and backend technologies, resulting in a modular and flexible microservice-based architecture. Figure 2 shows a screenshot of the *Story Editor View*. We achieve separation of

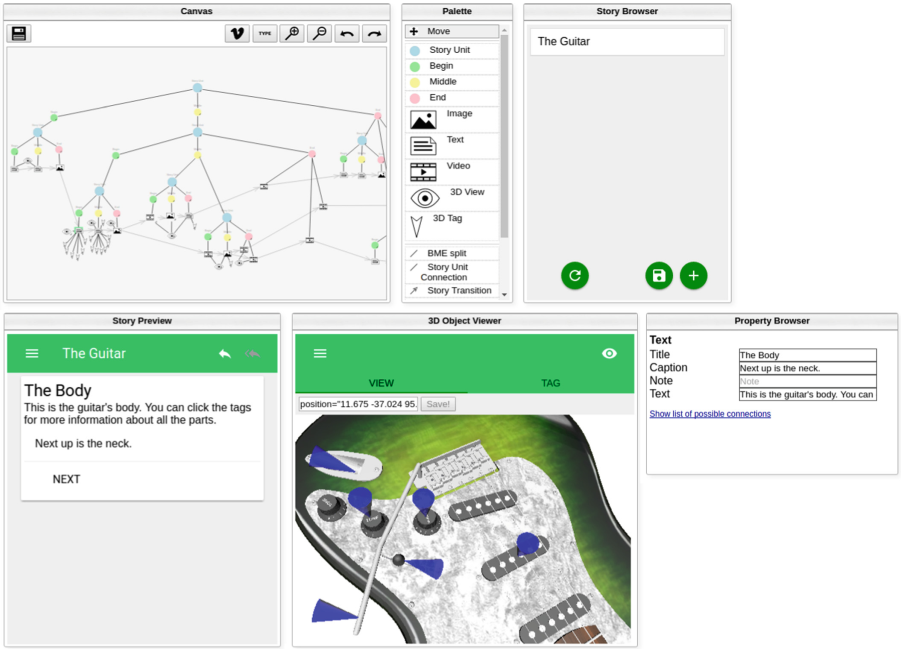

Fig. 2. Screenshot of the *Story Editor View*

functionalities by using Web widgets. These are standalone interface components with a clear-cut functionality, developed in JavaScript using the Google Polymer library[1], an implementation of the Web components W3C standard. Stories can be created collaboratively in near real-time using the *Palette* and *Canvas* widgets, which reflect an instantiation of the metamodel presented in Sect. 4. The *3D Object Viewer* widget contains the 3D object and its modification features. It uses the x3dom[2] JavaScript library to display the object, adjust camera positions and place tags. By clicking on a certain tag, a window containing text, images and/or videos opens. A "story transition" tag triggers a switch of the story page. When switching the story page, the camera automatically moves to the 3D view associated with it (if available) and the corresponding tags are shown. Users can also move the camera manually around the 3D object. The *Story Preview* widget displays the individual pages of the story and provides the navigation. Its content is updated in near real-time when changes in the model occur, in order to provide a live preview of the current state of the story. The *Story Browser* enables save and load functionality of stories. In the backend, RESTful microservices ensure the persistence of stories and perform semantic model checks upon changes. When a semantic error occurs in a story (i.e. the story is not compatible with the metamodel), a detailed description is passed

1 https://www.polymer-project.org.
2 https://www.x3dom.org.

to the frontend to inform the author. The story consumer view (not depicted in the screenshot) contains the *Story Browser* widget and additionally two widgets very similar to the *Story Preview* and the *3D Object Viewer* widget. It only lacks the editing options in the latter two, which are only available in the story editor view, that can be accessed at any time via the story browser widget. The system is available as a collection of open source projects in GitHub[3,4].

6 Evaluation

Methodology. We evaluated our approach in two ways. We recruited our first participant group from university students and staff of different fields. Our goal was to evaluate the compatibility of storytelling and 3D objects and how the collaborative aspect of our solution is adopted and rated by the end-users. The user evaluation was conducted in group sessions of one hour with two participants each and a total number of 12 participants, resulting in six sessions. After a short introduction to our prototype, the participants started to work on predefined tasks. The first task was to consume a demo story. In order to evaluate later how intuitively the story viewer could be used, we did not provide a detailed UI-explanation on the task sheet. One of the pages of the story simply contained a “To do” message. When both participants of a session walked through the story to one of the endings, we asked them to go back to this page. They then had to switch to the *Story Editor View*, in order to collaboratively replace the mentioned page with meaningful content. The task sheet contained different sub-tasks for each participant, ensuring that they collaboratively created a sub-story, integrated into the overall story. This also included tagging certain aspects of the 3D model. At the end of the session, the participants were asked to fill out a questionnaire. We also evaluated our approach with a domain expert in the field of teaching medicine in order to assess the applicability of our approach for informal learning. Here, we did not prepare a fixed set of tasks, but rather provided a series of tutorial videos[5] on how to use the editor and the concept of MOD. This way, the domain expert was provided with enough information to acquire experience with the tool autonomously during a longer usage period. After two weeks, he was asked to author a custom story from scratch. This allowed a least-biased view on the system, giving us as much insight into its perception and room for improvement as possible. We prepared semi-structured interviews, with a focus on open questions, which contained specific questions around the concept of story structuring and inquired about the functionalities of the editor.

User Evaluation Results. One main focus regarding usability was the intuitiveness of the story consumer view. This was rated with a good score of 4.33 ($\sigma = 0.49$) on average, with comments being very positive (“Very simple and

[3] https://github.com/rwth-acis/3DStorytelling.
[4] https://github.com/rwth-acis/las2peer-3DStorytelling.
[5] https://www.youtube.com/watch?v=enKijrMpYe0.

intuitive"). As a critique point, the participants commented that it was sometimes not obvious, when one has to decide between multiple options for the next story page. During the session we made the interesting observation, that many users tend to only click the rightmost button in the first run. Afterwards, we tried to already deal with this by simply highlighting the buttons to better separate them from the background and each other. However, we cannot rule out that this could have influenced the perception of our participants during the evaluation. For the story editor view, a user stated that she understood and valued the usefulness of the tool after about 20 min into working with it. The live preview aspects of the widgets in the *Story Editor View* were rated 4 ($\sigma = 1.13$). Although rather high, the feature requires slight implementation improvements due to its prototypical nature during the evaluation ("Widgets sometimes need to be reloaded", "Just sometimes I had to refresh the canvas myself"). One of our goals was to evaluate the acceptance of non-linear stories for educational purposes. This was a complicated task, as the participants only had a limited time to get familiar with the concept. The participants seemed to prefer the idea of non-linear stories both over linear ones, structured information without a story, and completely unstructured information. An average agreement-score of 3.58 ($\sigma = 1.13$) for "no structure" was the lowest of those options. Also very contentious was the question, whether the plot was helpful for keeping the participant interested. It was answered with an average score of 3.4, but with $\sigma = 1.43$. It sadly allow no profound conclusion. Again, factors that might have influenced this result were the limited time of the sessions and of course the perception of the individual demo story we used. With an average rating of 4.5, the participants said that they appreciated the functionality for having a second look at certain information and, with a very high score of 4.75 ($\sigma = 0.45$), for choosing in alternative story path. This highlights one fundamental challenge with non-linearity in digital storytelling. If one's goal is to learn, one will feel like missing something, as soon as one has to decide between various different paths. One participant clearly stated "Because of the not linear story I have not seen every part of the information and thus have not learned everything that I could have". Another point within the conceptual questions was to find the ideal use case for our system. We asked the participants how much they would appreciate non-linear storytelling for learning purposes in different scenarios. The results showed an increase in acceptance with decreasing formality, with a lowest average score of 2.92 for university education, and a highest average score of 4.42 for museum-like websites. A question regarding both future work and the potential of near real-time collaborative story editing, was about the different editing workflows. While the collaboration in general was perceived very positive, the participants seemed to appreciate workflows in which they interfere with each other the least. Their most appreciated workflow was working separately on own parts of the story, closely followed by having different roles (like "Story Scaffolder" and "Media Producer", as we also provided in the given tasks). Working unorganized had the least approval. Organization seems to be a very important aspect of the collaborative editing, with one participant for example suggesting the use of a voice chat. As a matter of fact, one observation we made was that the teams finished the tasks faster and more accurate, the more they communicated with each other.

Domain Expert Evaluation Results. The results of our second evaluation indicate that overall, the reviewer felt comfortable in using the editor after viewing the tutorial videos. While very positive about non-linearity of stories, he was doubtful about MOD. It turned out, that he intended to use our system for creating content in the direction of flexible online courses, rather then "explicit" storytelling. Although he appreciated the idea of a BME structure, he wanted each of those components to potentially be longer then just one media object. Especially in the case of a *Middle* object, he wanted to use multiple consecutive ones, to do more extensive explanations. Another suggestion was, to create "excursions" inside the story. These would be optional sub-stories, that return to their entry point when finished. While this concept is surly interesting to invest, it is hardly compatible to MOD. Aside from that, he appreciated the idea of also building stories around multiple objects and separately displayable parts of the same object. He also liked the idea of having the possibility to hide certain parts of the story graph in order to reduce its complexity while editing.

Implications for Future Work. It can become challenging to tell a long story using only a single 3D object. We consider the possibility for including multiple 3D objects into a single story to be a relevant direction for future work. However, this has to be reflected in the metamodel and the complications introduced into the story modeling process need to be computed. Approaches that introduce different modeling views could be a solution for this. Non-linear storytelling for learning purposes appears to be complicated without providing a way to revisit previous decisions. Without MOD, this problem would be manageable by allowing story branches to return to their origin by design. It is then up to the author to structure the story in a way, that no important information can be missed, and up to the consumer to trust the author. With MOD this is not the case, as backward transitions are a clear violation of the paradigm. The implementation of some way to return to previous story sections seems to be inevitable for a good user experience and for effective learning. Another challenge for future work is the possibility for optional excursions mentioned in the evaluation. We also recognized the need for the possibility to provide multiple media/pages per movement. Finally, we are currently working on enhancing story consumption with augmented reality, where the 3D objects can be explored in even more engaging ways, while consuming the story attached to them.

7 Conclusions

In this paper, we presented an approach for near real-time collaborative, non-linear storytelling around 3D objects on the Web based on a well-defined metamodel. The collaborative aspect of our approach enables new ways of how stories can be created and enhanced. Future work in this domain may highlight the benefits of this kind of collaboration and provide additional valuable insights in the dynamics of the collaborative aspects. The connection of storytelling with 3D objects is novel and our evaluation provides first insights into the usefulness of this approach. We strongly believe that both storytelling as well as digitizing real-life artifacts are two great ways for improving (informal) learning processes, and the combination of both provides interesting and promising results, which build the basis for future work in this domain. With our contribution, we provide a first step in this direction and give first impressions of the power and expressiveness this new way of interactive non-linear storytelling provides. We are confident that future research in this domain and applications in the form of interactive stories available via the Web, will provide great new ways of informal learning with collaborative, non-linear storytelling.

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References

1. Bransford, J.D., Brown, A.L., Cocking, R.R.: How People Learn: Brain, Mind, Experience, and School. National Academy Press, Washington, D.C. (1999)
2. Brown, J.S., Duguid, P.: The Social Life of Information. Harvard Business Review Press, Brighton (2000)
3. Cao, Y., Klamma, R., Martini, A.: Collaborative storytelling in the Web 2.0. In: First International Workshop on Story-Telling and Educational Games (2008)
4. Freytag, G.: Die Technik des Dramas. Hirzel, Leipzig (1872)
5. Kaplan, T.J.: Reading policy narratives: beginnings, middles, and ends. In: The Argumentative Turn in Policy Analysis and Planning, pp. 167–185 (1993)
6. Kiourt, C., Koutsoudis, A., Pavlidis, G.: DynaMus: a fully dynamic 3D virtual museum framework. J. Cult. Herit. **22**, 984–991 (2016)
7. Liu, C.C., Liu, K.P., Chen, G.D., Liu, B.J.: Children's collaborative storytelling with linear and nonlinear approaches. Procedia-Soc. Behav. Sci. **2**(2), 4787–4792 (2010)
8. Lukosch, S., Klebl, M., Buttler, T.: Utilizing verbally told stories for informal knowledge management. Group Decis. Negot. **20**(5), 615–642 (2011)
9. Nicolaescu, P., Toubekis, G., Klamma, R.: A microservice approach for near real-time collaborative 3D objects annotation on the Web. In: Li, F.W.B., Klamma, R., Laanpere, M., Zhang, J., Manjón, B.F., Lau, R.W.H. (eds.) ICWL 2015. LNCS, vol. 9412, pp. 187–196. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-25515-6_17
10. O'Keefe, J., Nadel, L.: The hippocampus as a cognitive map. Behav. Brain Sci. **2**(4), 487–494 (1979)
11. Schumann, J., Buttler, T., Lukosch, S.: An approach for asynchronous awareness support in collaborative non-linear storytelling. Comput. Support. Coop. Work **22**(2–3), 271–308 (2013)
12. Sharda, N.: Applying movement oriented design to create educational stories. Int. J. Learn. **13**(12), 177–184 (2007)

13. Spaniol, M., Klamma, R., Sharda, N., Jarke, M.: Web-based learning with non-linear multimedia stories. In: Liu, W., Li, Q., W.H. Lau, R. (eds.) ICWL 2006. LNCS, vol. 4181, pp. 249–263. Springer, Heidelberg (2006). https://doi.org/10.1007/11925293_23
14. Wenger, E.: Communities of Practice: Learning, Meaning, and Identity. Learning in Doing. Cambridge University Press, Cambridge (1998)

Game-Based Learning

A Mobile Game-Based Virtual Reality for Learning Basic Plant Taxonomy: Contextual Analysis and Prototype Development

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Abstract. Taxonomy is one of the leading topics in providing basic understanding about the components of biodiversity. It is necessary for effective decision-making on conservation and sustainable use on many aspects. However, teaching plant identification is found difficult due to the variability in the plants' appearance, bringing plants into the classroom, and taking students into the actual field. Based on this perspective, a mobile game-based learning application was proposed. Virtual Reality (VR) technology was used in the game for encouraging self-learning on plant taxonomy education. In this study, a game prototype was developed by taking a learning context of a science high school in Thailand as a case study; in the meantime, the campus location was served as a learning scenario. In this game, spherical photos of selected plants were embedded in a storyline; while game quests and stories were presented in 3D objects. Students can learn and play this VR game by their mobile devices equipped with any VR box sets, while remote controllers can be a perfect companion of this game for a better gaming experience. In summary, this VR game is expected to serve as self-virtual authentic learning for any students to learn plant taxonomy topic with more learning motivation and enjoyment.

Keywords: Mobile game-based learning · Plant taxonomy · Science education Virtual reality

1 Introduction

Everything in Science must have name [1]. Taxonomy gives essential comprehension about the components of biodiversity. It is vital for powerful selection-making approximately conservation and sustainable use. United Nation launched the United Nation Decade on Biodiversity (UNDB) during 2011–2020 to break the lack of biodiversity in order to make certain that by 2020 ecosystems are resilient and preserve to provide essential services, thereby securing the planet's from of life, and contributing

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to human properly-being, and poverty eradication [2]. Among them, plant identity requires an incredible deal of study to master.

Among organisms, plants are possibly the most difficult, not least for the reason that most undergraduates have very little preceding exposure to them [3, 4] and thus have little interest in studying their names. Possibly because of this lack, pictures of plants are harder to consider than are pictures of animals [5]. Teaching plant identification is tough wing to its variability in the plants' appearance, bringing plants into the classroom, and taking students into the actual field. Inadequate exposure to the plants in the classroom makes the students facing a difficulty to generalize the novel examples when they are run into the field. Even though field botany courses are effective at teaching plant identification but they are both labor and time consuming and have been falling out of use in a large number of students in class.

In the past decade, the use of computer applications has become popular in addressing this learning flaw. Recently, Virtual Reality (VR) technology has played an essential role in shifting the conventional multimedia to a more immersive, interactive, intuitive and exciting VR learning environment. It can simulate the real world through the application of 3D models that starts interaction, immersion and trigger the imagination of the learner [6]. Huang 2010 suggested that learning from interacting with an artificial real environment can promote creativity, motivating learners to learn, and could be a scaffolding tool for learners to learn. VR was applied to many fields such as engineering, medical and education and revealed positive results to the learners [7, 8].

Based on this perspective, this study proposed a development of VR learning application for Plant Taxonomy. Mobile game-based learning strategy was employed to make this application more engaging and meaningful. Particularly, this paper aims to present an instructional design prototype of VR learning environment, as a preliminary study. An analysis of learning context has been carefully conducted, while a game scenario and character design have been designed based on VR game learning activities as a story. A VR application prototype has been developed accordingly. Therefore, this study was directed with following research questions:

(1) What are reliability and validity of the content on the proposed prototype development?
(2) Do the students have satisfaction towards the proposed prototype development?

2 Related Studies

2.1 Educational VR

Virtual Reality (VR) is a newly emerging computer interface characterized by high degrees of immersion, believability, and interaction, with the goal of making the user believe that he or she is actually within the computer-generated environment. Virtual reality implementations typically use high speed, high quality three-dimensional graphics, and specialized hardware such as head-mounted displays and wired clothing to achieve high degrees of realism and believability [9].

In the past years, VR has been developed in a wide range of applications. For example, an educational application of virtual reality was designed to support in the teaching of undergraduate chemical reaction engineering for different learning styles [9]. In medical education, VR is used as human physiology learning environments wherein students can interact with others while carrying out a set of mission [8]. In Science education, a VR modeling tool is used to sketch 3D visualization designs of scientific modelling subjects. It was found that artists, illustrators, and designers were able to consistently provide valuable insight in addressing difficult visual problems in science. Game-based learning environments were more effective than virtual worlds or simulations, with overall effect sizes that were roughly twice as large [10].

Therefore, in this study, the benefits of VR such as immersion, interaction, motivation and impression were adopted to help enhancing the students' interest on plant taxonomy topic.

2.2 Mobile Game-Based Learning

A mobility shift in the usage of media is characterizing today's society and influences the way people communicate, amuse and learn. Nowadays, mobile gaming and mobile learning are combined which called game-based learning therefore refers to the process of gaming and learning. Mobile game-based learning is still in its initial stage and a lot of further research is needed to understand the deeper connection between mobility, gaming and learning.

Mobile game-based learning is becoming increasingly popular now that mobile devices provide support for multimedia content, location awareness, augmented reality and connectivity. The challenge for game designers for mobile learning is to embed both effective gaming experiences and worthwhile learning outcomes into the same application [11]. The few existing research studies mostly mentioned design and development issues or present prototypes of mobile serious games. Study results indicate better collaboration and problem-solving skills in users [12], in addition to a significant knowledge improvement compared to the control group [13]. Using mobile technologies in direct physical interaction with space and with other players can be combined with principles of engagement and self-motivation to create a powerful and engaging learning experience. Mobile gaming might be employed as a tool for supporting learning.

In this study, mobile game-based learning was used to be a principle for considering our design of VR game prototype which needs to combine smoothly gaming experiences and learning outcomes into our prototype. The most powerful prototype will encourage the students to engage and self-motivate without teacher.

3 Contextual and Content Analysis

3.1 Contextual Analysis

In this study, a campus of Science high school in Thailand exploration activity was applied for Taxonomy class, in which students need to observe all tree plants in such area and collect the data. As shown in Fig. 1 (right), there are 320,000 square meters on this campus which was divided into seven zones. The original area was the mangrove forest but some were covered by soil and planted by fresh water trees.

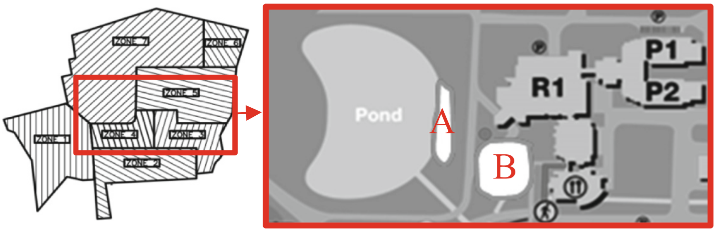

Fig. 1. A layout of school campus (left), a layout of studied context (right)

Based on the current curriculum, plant taxonomy is learned in "*Phuwiangosaurus sirindhornae*" course of grade 11. This course covers three main components of taxonomy including classification, identification and nomenclature. Classification is the process of a logical system of categories. Identification is the naming of an organism by reference to an already existent classification. Nomenclature is the study of the system and methods of naming organisms and the construction, interpretation and application of the regulations governing this system are covered.

In this study, total 12 plants were selected due to its valuable and safety to observe, as shown in Fig. 1 (right). There are four local mangrove forest trees in zone A (plants 3, 9, 10, 11) and seven imported fresh water plants in zone B (plants 1, 2, 4, 5, 6, 7, 8, 12).

3.2 Content Analysis

All selected plants can be grouped into nine family, as shown in Fig. 2, in which students can classify the plants by similar flower, fruit and seed. The exposure to plant family when playing the proposed game, lead the students to understand more about plant taxonomy principles and can distinguish various plant family easier (nomenclature: plant 1, 2, 3, 4, classification: plants 5, 6, 7, 8, and nomenclature and identification: plants 9, 10, 11, 12).

Fig. 2. Plants and family (bold)

4 Prototype Development

In this application, it was mainly developed by Unity and Microsoft Visual Studio for coding game system, user interface and game dialogue. Blender for graphic, 3D characters and interior design, Adobe Photoshop for photo editing, Adobe Premiere Pro was for VDO editing, Clip Studio Paint for 2D graphic, and FL Studio for sound editing and synthesis.

4.1 Overall Structure

In this game, the players need to use their knowledge of plants taxonomy to complete the 12 quests, facilitated with helpful information, challenges, and enjoyment, as shown in Fig. 3.

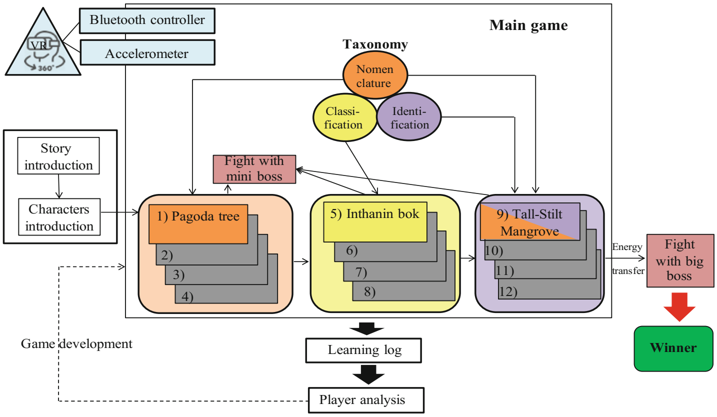

Fig. 3. Overall game structure

Story introduction will give more detail about the Anti-Wasseruchers league foundation and try to motivate the player to fight with monster. Character introduction is being inside the 3D object room such as starting room and laboratory room. The non-player characters are Prof. Punya, Alice and Wasserucher. The missions will be about finding suitable plants to extract its essence to fight big boss. Every mission will be involved with observations of plants in the area, by adding the ability to move around during the missions will give the player opportunity to spot more specific details for each plant to finish the missions. Player need to learn about plant family and memorize the important characteristics of each plant. Only the person who can complete all quests, can fight with big boss and win the game. The details included in the game are scientific names, classifying and the important characteristic of the plants.

Advantage of VR game is that users can experience full-view landscape of plant areas, e.g. Mangrove forest and interact with the game by Bluetooth controller and accelerometer. Bluetooth controller helps for selecting the function button, walking in the 3D scenes, answering the multiple-choice questions and shooting the monster. Head turning is a gesture that the player can use when their head was covered by VR headset.

4.2 Characters and Scenario Design

The characters are 3D-designed to be moveable and interactable with players. There are four 3D rooms including starting room, laboratory room, mini boss fighting room and big boss fighting room. All rooms are related to the game story and content sequencing. The main characters of this game are illustrated in Fig. 4.

Educator: Prof. Punya Receptionist: Alice Monster: Wasserucher

Fig. 4. Main characters in the game

Prof. Punya is the educator who helps student to learn by themselves and explore more understanding about plant taxonomy. Alice is the receptionist who helps to introduce how to play game and intro the story about Anti-Wasseruchers league foundation. The league was founded due to the outbreak of monster around the world. Their missions are to destroy all monsters and protect the living people in the world. Wasseruchers are the alien monster from outer space. They are in everywhere and killed many people. It is the monster who will give player a question to answer and finally, it become a big boss after player correcting 12 questions.

As shown in Fig. 5, these scenes will keep in the bookshelf of laboratory room. It will show when the player clicks on the book for learning more about the plant. Prof. Punya will help giving a mission such as gather red mangrove forest and give the hints such as near the water and bigger one. Then, the player can take a look in the bookshelf and learn more about that plant. If the player thinks that he/she knows enough, he/she can move to question-answer process. The correct answer of every three questions is moving to fighting with mini boss.

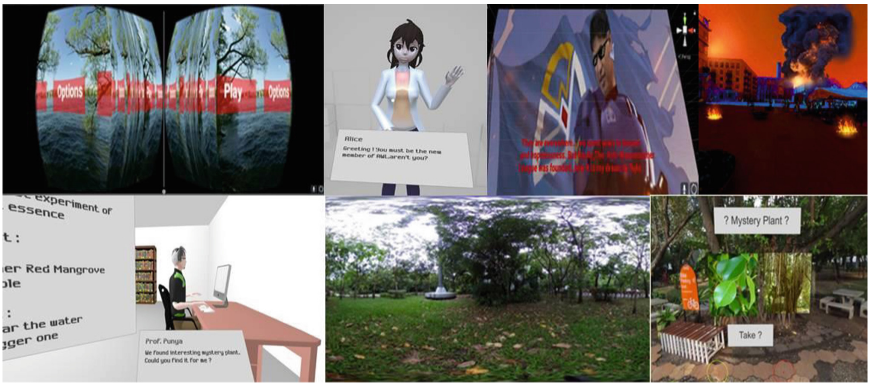

Fig. 5. Example screenshots of game scenarios

4.3 Description of Prototype and Learning Activities

In this game prototype, students are required to learn by following the game scenarios, as shown in Table 1. In the meantime, learning missions and activities are presented to interact with different gestures, as shown in Fig. 6.

Table 1. The relationship between game scene, mission and player interaction.

Scene	Mission and learning activity	Player interaction
Starting room	Player meets with Alice and she will help introducing how to play the game. The player gets the mission to find the plants and fighting with Wasseruchers	Watch introduction and get the mission. Press to play the game
Laboratory room	Player meets with Prof. Punya to learn about Plant family classification or unique characteristics of plant and get the hint. Give mission to player. The player needs to find the plant that suitable for extraction	Learn content of plant taxonomy. Watch plant characteristics such as leave, stem, flower, root and fruit. Press to choose the information such as plant taxonomy, plant family and plant characteristics. Walk around the lab to interact with the documentary, extract the plant and discuss with Prof. Punya
Question asking	Monster asks the question one by one. If the answer is correct, the player can fight with mini boss after correct every three questions. The 12 questions about plant nomenclature, classification and identification is asked using 4 multiple choice questions	Learn to answer the taxonomy questions. Watch the questions. Press to answer the question
Mini boss fighting room	The player fights with mini boss to practice their fighting skills	Learn how to fight with mini boss. Watch the movement of mini boss. Press to shoot the gun. Face moving to move the gun around
Big boss fighting room	After finishing 12 missions, the player needs to fight with Wasseruchers. If the player wins, he/she will complete the game	Learn how to fight with big boss. Watch the movement of big boss. Press to shoot the gun. Face moving to move the gun around

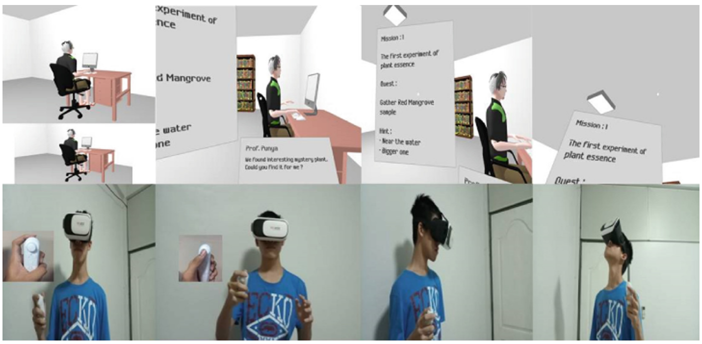

Fig. 6. Screenshots with player gestures

5 Evaluation and Results

5.1 Content Evaluation

After the content analysis was done, it was proved by three invited experts on plant taxonomy. A 5-point Likert scales questionnaire of seven items about the content accuracy and reliability was used to evaluate the basic plant taxonomy content. As shown in Table 2, it was found that the experts rated the content on this proposed game at medium level. This means that the content of this game would need careful reconsideration; particularly, the appropriateness of the content and the continuity of the learning sequence.

Table 2. Result of content evaluation.

Items	Mean	SD
The accuracy of questions and answers in the game	3.67	1.53
The accuracy of Plant taxonomy content	3.67	1.53
The suitable of content for student	3.33	1.15
Continuity and sequencing of content	3.33	1.73
The suitable between content and game mission	4.00	1.53
Reliability in diagnostic and diagnostic procedures of content	3.33	1.15
The suitable of VR game for reality using	3.52	1.35
Average	3.43	0.53

5.2 Prototype Evaluation

After the prototype development of a mobile game-based Virtual Reality for learning basic plant taxonomy was done, the preliminary experiment has been performed with 48 participants in order to examine the prototype satisfaction. A 5-point Likert scales questionnaire of VR Game Interaction (5 items) and Graphic User Interface (6 items) was used to evaluate the prototype after all participants played the game. The result was shown in Table 3 with the medium level of satisfaction by the users' sample. This finding revealed that the game interaction in VR learning environment and its game user interface were acceptable; however, an improvement regarding these issues are expected to reach the higher satisfaction and better learning experience.

Table 3. Result of the prototype satisfaction.

Items	Mean	SD
VR game interaction	3.57	0.85
Graphic user interface	3.56	1.15
Average	3.56	1.02

6 Conclusion

This study proposed a contextual analysis and prototype development of a mobile game-based Virtual Reality for learning basic plant taxonomy. The study showed a possibility of applying the game to motivate learner and enhance self-learning in field of plant taxonomy. Owing to the interaction and immersion of VR game, the proposed game could help motivating students to learn. The game was designed to the link between content and physical location.

This VR game is expected to serve as self-virtual authentic learning for any students to learn plant taxonomy topic with more learning motivation and enjoyment. Other practitioners or educators can apply this method to their own areas and follow our prototype development process. Furthermore, the authors are under the process of developing the completed game based on the findings of this study. More investigations can be carried out in the near future.

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References

1. Godfray, H.C.J.: Linnaeus in the information age. Nature **446**, 259–260 (2007)
2. Secretariat, C.B.D.: The Strategic Plan for Biodiversity 2011–2020 and the Aichi Biodiversity Targets. In: Document UNEP/CBD/COP/DEC/X/2, pp. 1–13 (2010)
3. Schussler, E.E., Carley, P.W.W., Staff, E., et al.: Guest editorial preventing plant blindness. Am. Biol. Teach. **61**, 84–86 (1999)
4. Link-pérez, M.A., Schussler, E.E., Link-pérez, M.A., et al.: Exploring plant and animal content in elementary science textbooks. J. Biol. Educ. **44**, 123–128 (2010)
5. Schussler, E.E., Olzak, L.A.: It's not easy being green: student recall of plant and animal images. J. Biol. Educ. **42**, 112–119 (2008)
6. Grigore, C., Burdea, P.C.: Virtual Reality Technology, 2nd edn. Wiley, Hoboken (2003)
7. Huang, H., Rauch, U., Liaw, S.: Investigating learners' attitudes toward virtual reality learning environments: based on a constructivist approach. Comput. Educ. **55**, 1171–1182 (2010)
8. Huang, H.-M., Liaw, S.-S., Lai, C.-M.: Exploring learner acceptance of the use of virtual reality in medical education: a case study of desktop and projection-based display system. Interact. Learn. Environ. **24**, 1–17 (2013)
9. Bell, J.T., Fogler, H.S.: The application of virtual reality to (chemical engineering) education. In: Proceedings of the IEEE Virtual Reality Annual International Symposium, pp. 217–218 (1997)
10. Merchant, Z., Goetz, E.T., Cifuentes, L., Keeney-kennicutt, W., Davis, J.: Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: a meta-analysis. Comput. Educ. **70**, 29–40 (2014)

11. Parsons, D., Petrova, K., Ryu, H.: Designing mobile games for engagement and learning. In: The 7th International Conference on Information Technology and Applications (ICITA 2011) Designing, pp. 261–266 (2011)
12. Sánchez, J., Mendoza, C.: Mobile serious games for collaborative problem solving. Stud. Health Technol. Inform. **144**, 193–197 (2009)
13. Huizenga, J., Admiraal, W., Akkerman, S., Dam, G.: Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. J. Comput. Assist. Learn. **25**, 332–333 (2009)

Making Understandable Game Learning Analytics for Teachers

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Abstract. When used for education, games can increase students' motivation and engagement and provide a more authentic learning environment where they can apply knowledge, making them especially suited to schools. However, actual application of such (serious) games in schools is still limited. Teachers still consider that using games is a complex process that they do not fully master and that requires extra effort from them. We consider that simplifying teachers' tasks when deploying games is crucial to promote their use. In classroom scenarios, teachers can greatly benefit from knowing what is happening as a serious game is being played. Game learning analytics (GLA) is the process of collecting, analyzing and displaying student interaction data with the games to improve the educational experience. GLA can be used both at real-time, providing teachers with information while their students are still playing, and off-line, inspecting already-finished game sessions. In both cases, analytics is only useful when it manages to bridge the gap between large collections of interaction data and pedagogically sound insight. Analytics dashboards should therefore provide not only complete but meaningful and easy-to-understand information, considering that teachers will most probably not know all the details of the analyses performed underneath. In this paper, we review our experiences on game learning analytics dashboards for teachers, and describe some of the steps we have taken to improve our dashboards.

Keywords: Learning analytics · Serious games · Dashboards · xAPI Game-based learning

1 Introduction

There are many characteristics that make games adequate for education, including their engaging and motivating nature [1, 2]. Despite these advantages, the adoption of serious games is still poor, partly due to a lack of standards for development, validation and deployment in schools [3]. Collecting and analyzing student gameplay is one of the keys to increase serious game adoption in schools, because collected data can provide insight and improve all steps in the process, and even become a major selling point in

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itself, thus driving adoption. In educational settings, Learning Analytics (LA) is used to provide insight into learners' actions to improve their learning process and contexts. When applied to games, Game Learning Analytics (GLA) [4] focuses on information gathered from players via in-game interactions.

Figure 1 represents a generic Game Learning Analytics pipeline, focusing of two main stakeholders: students playing a serious game, whose information is tracked, stored and analyzed within the Analytics System; and teachers supervising the game session. Analyses and visualizations (embedded in a dashboard) provide information for teachers. Other stakeholders, such as students themselves, game developers, and academic officials can be presented with their own dashboards.

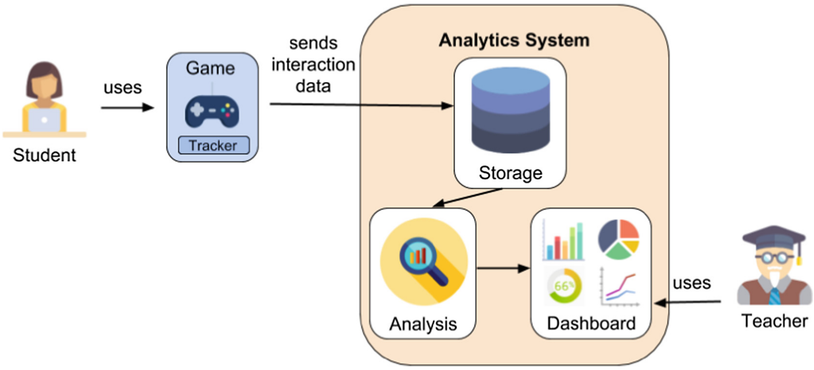

Fig. 1. Game Learning Analytics pipeline: a student plays a game that includes a tracker component. The tracker sends interaction data to the Analytics System for storage, analysis and visualization. Teachers, among other stakeholders, interact with dashboards to gain insights into student gameplay and educational outcomes.

Dashboards are the usual way to communicate information to stakeholders [5]. They can display important metrics, and provide a visual overview of other information while allowing filtering and limited query capabilities to gather more in-depth data. Among the usual stakeholders of interest for game learning analytics (students, teachers, game developers), this paper focuses on teachers, as they oversee the actual educational environments and are, in our opinion, the first stakeholder that needs to be considered to improve analytics for games in education: student dashboards are also important, but teachers are who decide whether or not to use games. More narrowly, the last step of Fig. 1 depicts the teacher using the dashboard, which requires teacher dashboards to be understandable, as described in [6].

Generating teacher dashboards starts with tracking interaction data, which must be done with care to guarantee privacy. Interaction data can then be displayed in different visualizations, for example displaying previously-identified KPIs *(Key Performance Indicators)*, the choice of which will be different from other stakeholders. Data collection and analysis should be entirely transparent to teachers. The final step, the visualization of the information, is where game learning analytics can provide value to teachers. In this sense, dashboards need to be evaluated as pedagogical tools, taking into account their goals, affect and motivation, and usability [7].

The process of collecting, analyzing and displaying data from in-game interactions to yield useful teacher dashboards comprises several steps, each of them beset by possible issues:

a. Data collection: Collected interaction data cannot be easily shared unless a collection standard is being followed. Once standardized, privacy issues need to be addressed. Furthermore, what data should be captured depends on the games, and game developers are understandably more interested in designing games – rather than selecting what to send and then, on top, having to perform anonymization and sending it according to specific standards. While data collection is not, in itself, an issue that is specific to teacher dashboards, decisions made at this step (particularly what is collected and how it is anonymized) greatly influence dashboard outcomes.
b. Low teacher expectations: Teachers are often new to analytics dashboards, and do not really know what to expect. In our experience, when asked what they expect to see, teachers described only basic information, such as times of completion, difficulty, results in terms of counts of right and wrong answers, or number of attempts; possibly displayed using simple visualizations. Also, teachers assume that analytics will only be available after the intervention, and do not expect to receive any information while students are playing.
c. Dashboard design: The design space of possible dashboards is vast, and designing useful visualizations requires both pedagogical knowledge and game-specific information. Teachers are generally not experts in dashboard design (see point *b* above); and are unwilling to make significant investments in dashboard design upfront, before the game is even available.
d. Changing dashboard requirements: Teachers will often request additional visualizations for their dashboards after the game has been played (see points *b* and *c*). Fulfilling these may be costly or even impossible (for example, if the requisite data was not originally collected; see point *a*) – unless the whole system has been designed to allow the necessary flexibility.
e. Beyond stand-alone games: Teachers may want to use games as parts of larger courses, which may in turn be games as well. In these cases, dashboard granularity needs to be configurable, allowing the game to be analyzed not only by itself, but also as a part of a whole, and even as a whole with several parts.

As participants in two EU H2020 Projects, we have developed a complete architecture to track, collect, store, analyze and display the data collected from serious games in a systematized way [8, 9]. Section 2 of this paper describes how our architecture, and specifically our teacher dashboards, tackle the above issues. Section 3 describes how teacher dashboards could look like in subsequent iterations. Finally, Sect. 4 summarizes our conclusions and outlines future work.

2 Improving Teacher Dashboards

For data collection (issue *a* in the previous section), we use the Experience API for Serious Games Profile (xAPI-SG) as a standard collection and archival format. xAPI-SG defines a common set of interactions that are usual in serious games, as detailed in [10]. We provide an easy to use library that greatly simplifies adding analytics to serious games, isolating game developers from the details of the standard. To avoid privacy issues, we use pseudonymous tokens for students. Tokens are unique strings of 4 characters created at the server when the game is deployed, and provided by teachers to their students, who will then use them to access the game. We then rely exclusively on tokens to identify students across play sessions, using them also to display information in the visualizations. Only teachers can, if they choose, keep the correspondence between tokens and actual students.

Regarding low teacher expectations and dashboard design (issues *b* and *c* in the previous section), since we cannot expect teachers to provide detailed lists of what should be analyzed and how it should be displayed, we have developed a default dashboard, which does not require any setup and can display basic data for any game that sends valid xAPI-SG interaction data. For example, since xAPI-SG has a specific vocabulary to indicate that a student has made a choice, and whether the game considers the choice to be correct or not, the default dashboard can easily display counts of correct/incorrect student answers. The use of a default, generic dashboard immediately provides value to teachers, and provides a useful base to elicit requirements for more complex game-specific dashboards.

Additionally, since our dashboards are updated in near real-time, with delays of few seconds between receiving interactions and displaying updated visualizations, we also include a simple alerts and warnings mechanism that can be configured to notify teachers of possible issues as they arise. We consider alerts to be higher-priority than warnings, but the underlying mechanism is the same; and, asides from increasing the situational awareness of teachers, its existence reminds teachers that the use of analytics is not limited to presenting post-mortem information on playthroughs; and that their role during gameplay sessions need not be limited to proctoring.

To provide the necessary dashboard flexibility (issue *d* above), we are not limited to the default dashboard, and allow game developers (presumably with teacher feedback) to create customized game-specific analyses and visualizations for their games. Since our dashboards are built on top of the Kibana and ElasticSearch open-source projects, dashboard creation is developer-friendly, although not recommended for non-programmers. If need be, custom analyses and dashboards can re-evaluate old data, allowing dashboards to be updated to display existing information in new ways. This allows requirements to evolve as teachers and game designers refine their understanding of how students play and learn with a serious game, or when dashboard usability issues are identified. Subsects. 2.1 and 2.2 contain two case-studies of such custom game-specific dashboards.

Finally, regarding issue *e*, games are sometimes part of more complex course structures. For example, a game may contain several mini-games, each of which can merit its own dashboards. However, it still makes sense to provide a global dashboard to monitor progress across all the minigames. This functionality was required for the H2020 EU Project BEACONING and allows for multi-level analytics, where the results of, for example, games that launch other mini-games, can be combined and meaningfully analyzed and displayed to provide insights on overall progress.

2.1 A Custom Dashboard for a Serious Game on Cyberbullying Awareness

Conectado [11] is a serious game to raise awareness against cyberbullying by placing the students in the role of a transfer student that suffers bullying and cyberbullying after arriving at a new school. Players experience the life of this transfer student in first person, during each of 5 in-game days, while being exposed to feelings of impotence and increased (in-game) social isolation. The game keeps track of the level of friendship of the story's protagonist with each classmate. For instance, the variable called *friendship risk* indicates, based on the player's choices, the risk of being bullied in the game from 0 to 100, where a higher value corresponds to a worse social standing. There are indicators of risk for each character as well. The decisions that players make during the game, including whether the player decides to tell that is being bullied to the parents or the teacher or not, also determine the ending.

Some of the game-dependent visualizations developed for *Conectado* can be seen in Fig. 2. From left to right, and from top to bottom:

a. Average friendship risk: this general metric describes whether the average of the class has low, medium or high friendship risk (shown in green, yellow and red, respectively).
b. Number of players per game day: this bar chart provides a vision of the progress of players in the game. As there are five days, teachers can see in real-time how many students have played through each in-game day, and help students who are too far behind their classmates.
c. Number of players that have taken each possible action that determines the ending: this pie chart compares the number of player who have decided to complain about bullying to the in-game parents and teachers vs. those that have decided to remain silent.
d. Maximum friendship risk per student: this visualization provides more in-detail information that complements the general metric provided in the first visualization. This allows teachers to quickly identify which students are doing best and worse in the game. Since the visualization is sorted, it also provides an overview of the distribution of risk scores throughout the class.

These visualizations have been designed trying to cover some of the information usually required by teachers: progress (b), decisions taken (c) and specific metrics, both general (a) and per student (d).

By default, in our teacher dashboard, all visualizations were of the same shape and size. However, different sizes are possible as seen in Fig. 2. In some cases, this may even be required to fit the desired visualizations, as it is the case in the next example where a plug-in was created to provide the exact visualizations desired.

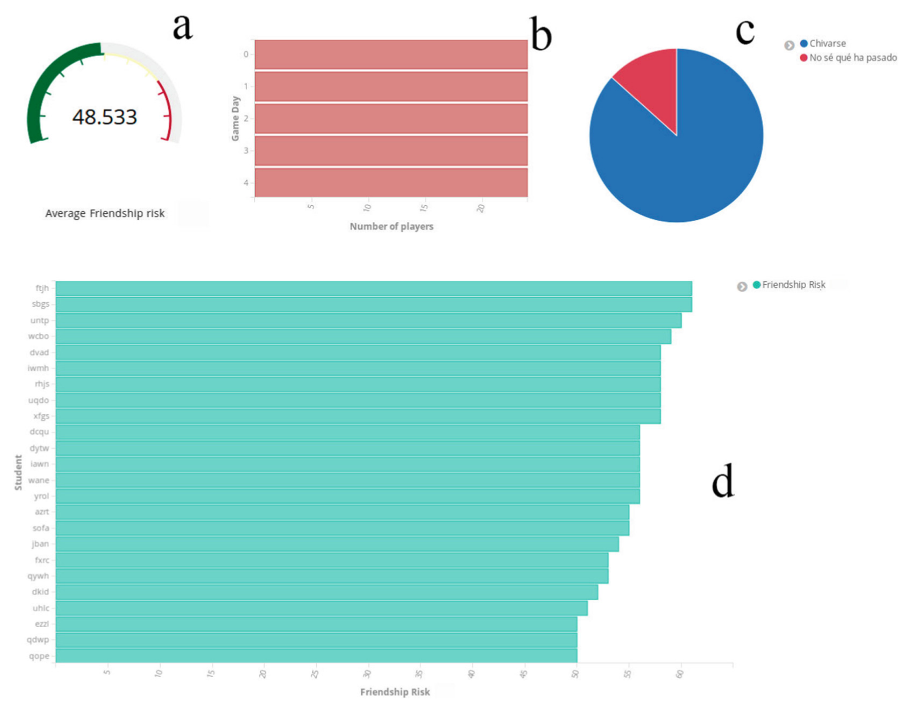

Fig. 2. Some of the game-dependent visualizations developed for the game *Conectado*. (Color figure online)

2.2 A Custom Dashboard for a Serious Game on Workplace Interaction

Another scenario where both analysis and visualizations were developed ad-hoc was for a game centered on workplace interactions developed for the EU H2020 RAGE project. The game design included a requirement to use the Thomas–Kilmann Conflict Mode Instrument (TKI) to measure and display responses to the different conflict situations that the player is exposed to while working as a team leader in a simulated game development company. The TKI is based on two dimensions of behavior, assertiveness and cooperativeness; and defines five different approaches based on the balance between both dimensions: competing, accommodating, avoiding, collaborating and compromising. A specific analysis and visualization was developed to display the TKI categorization for each player. Additionally, certain situations allowed the player to exhibit, or avert, certain types of biases (for instance, based on gender, race, or fashion sense). Finally, the game allowed players to track office morale, productivity (in terms of shipped games), and awards for quality.

Figure 3 displays the seven visualizations developed for this dashboard:

a. Thomas-Kilmann classifications of a specific student's answers over time.
b. Games shipped, a measure of team productivity.
c. Awards won, a measure of team quality.

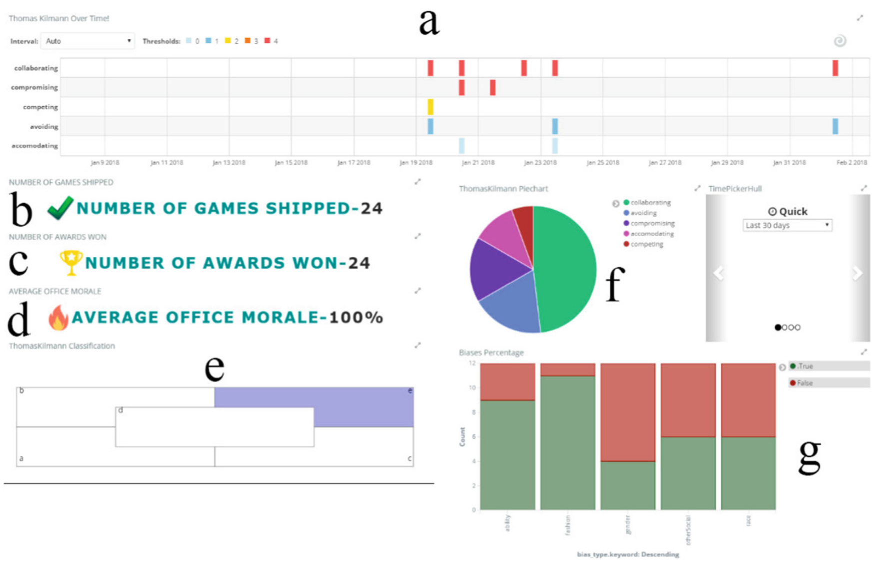

Fig. 3. Some of the game-dependent visualizations developed for the Thomas-Kilmann Conflict Mode Instrument. (Color figure online)

d. Office morale, a percentage indicating the degree to which the player's in-game co-workers are happy with the player's choices.
e. Overall Thomas-Kilmann classification for the player, displaying the category that has appeared more times from the five pre-set categories. This visualization is part of the standard TKI.
f. Pie chart displaying the distribution of answers according to the 5 TKI categories.
g. Bar chart displaying, for each bias, the ratio of responses where it was averted (green) or exhibited (red). Note that both counts are relevant, as most possible choices to the in-game conversations did not offer the opportunity to either avert or exhibit a bias.

This set of visualizations was a specific request made by the creators of the game in the project, sought to display all the information they considered to be of relevance in the game, and underwent several cycles of prototypes/changes until reaching its final iteration as displayed above.

3 Lessons Learnt in Teacher Dashboard Design

We have tested the default teacher dashboard, including an alerts & warnings visualization, in experiments with two games, played under experimental conditions by over 600 students and 150 teachers. Based on feedback from these experiments, we are currently redesigning the default dashboard to make it more understandable and actionable for teachers.

To make visualizations more understandable, we have completely reworked their names and labels, with a focus on clarity; and are including pop-up descriptions for the more complex visualizations. For instance, in Fig. 3, the visualization of biases exhibited/averted (*g*) requires, at first, a significant description to understand what is being displayed; but once understood, there should be no further need for bringing up the description, and it should therefore not receive permanent display space. Additionally, as can be seen from Fig. 3, we now allow dashboards to combine visualizations of different sizes, so that more visually complex visualizations can be rendered in larger areas. At first version all of visualizations were of the same size and at the second version, we had two possible sizes (Fig. 2). Also, while in the initial teacher dashboards the positions of individual visualizations were not fixed, we have now made positioning entirely predictable and controllable. This has considerable advantages when comparing the dashboards for different experiments based on the same game, for example.

Making a dashboard more understandable also makes it easier for teachers to reason on the underlying information, and to take actions based on these decisions, which is the goal of any analytics system: to induce new meaning or change behavior [12]. Therefore, usability is an important first step towards actionable feedback. We are also exploring other avenues to provide recommended actions for teachers. For example, we are considering the use of alerts to highlight statistical deviations from a baseline. This

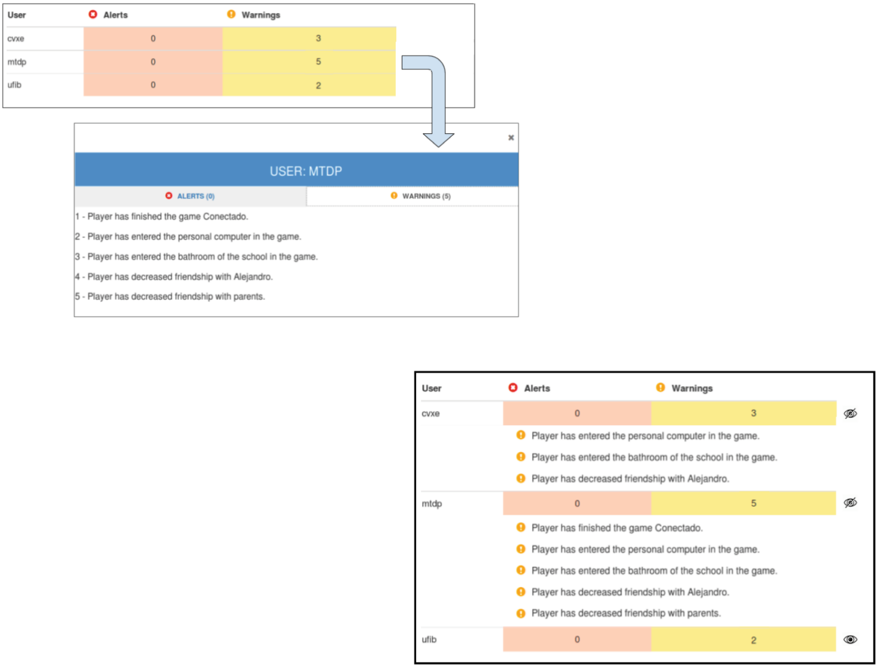

Fig. 4. Previous (top) and updated (bottom) alerts & warnings view. The previous display only counts of alerts and warnings; teachers had to click on student names to view the actual alerts and warnings for those students. The updated version does not require such a context switch.

would first require sufficient baseline data to be gathered; for example, we can take all completion times from a validation run, and use these times to identify students who take significantly longer (say, one standard deviation) than their colleagues to finish. Since this analysis can be performed regardless of the game, it can be rolled into the default alerts system, benefitting all future users of the analytics system at essentially no increased cost for users. The view of alerts and warnings can also be improved, by making a better use of display area; for instance, showing triggered alerts and warnings directly in the general view if they are not too many, or showing only the most recent otherwise.

Figure 4 depicts two versions of the general view of the alerts and warnings each student has triggered. In the original version, teachers must click on a student's name or access token to see the detailed alerts and warning that the student has triggered. In the updated version, teachers see details for each student directly on the main view.

As an upcoming approach, alerts could be used after validation of games to provide extra information: for instance, alerts could be deployed to identify students who are taking much longer than the expected time and show an alert in correspondence, helping to identify the outliers in terms of completion times.

4 Conclusions

Teachers are key to increasing adoption of serious games by schools, and Game Learning Analytics should therefore focus on their specific needs. We consider that teachers' requirements should determine what information is to be collected and analyzed, to be later displayed on dashboards that are easy to understand for an average teacher. Dashboards should help teachers to make informed decisions not only after the games are played, but also while the game is ongoing and teacher interventions are still possible to help players make the most of their sessions.

In this paper, we have identified several issues with teacher dashboards, including privacy and data collection, low teacher expectations regarding the outputs of the dashboards, lack of initial input when creating initial dashboards vs. late dashboard design requirements, and the use of dashboards for non-standalone games; and we have described how we have met these challenges by using simple anonymization via tokens and the xAPI-SG standard, a default set of visualizations that provides teachers with quick and easy-to-understand information to act on the previous contexts, support for custom-built dashboards (we present two case-studies), a flexible alerts and warnings system, and hierarchical dashboards.

In our experiments using these dashboards, we have identified possible improvements (including alerts and warnings) to make them more understandable. These will be implemented on subsequent iterations, and tested and validated using the *Conectado* serious game and other games from RAGE and BEACONING H2020 projects.

References

1. Connolly, T.M., Boyle, E.A., MacArthur, E., Hainey, T., Boyle, J.M.: A systematic literature review of empirical evidence on computer games and serious games. Comput. Educ. **59**, 661–686 (2012)
2. Denis, G., Jouvelot, P.: Motivation-driven educational game design: applying best practices to music education. In: Proceedings of the 2005 ACM SIGCHI International Conference on Advances in Computer Entertainment Technology (2005)
3. Loh, C.S., Sheng, Y., Ifenthaler, D.: Serious Games Analytics. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-05834-4
4. Freire, M., Serrano-Laguna, Á., Iglesias, B.M., Martínez-Ortiz, I., Moreno-Ger, P., Fernández-Manjón, B.: Game learning analytics: learning analytics for serious games. In: Spector, M., Lockee, B., Childress, M. (eds.) Learning, Design, and Technology, pp. 1–29. Springer, Cham (2016). https://doi.org/10.1007/978-3-319-17727-4_21-1
5. Shoukry, L., Göbel, S., Steinmetz, R.: Learning analytics and serious games: trends and considerations. In: Proceedings of the 2014 ACM International Workshop on Serious Games (2014)
6. Schwendimann, B.A., Rodriguez-Triana, M.J., Vozniuk, A., Prieto, L.P., Boroujeni, M.S., Holzer, A., Gillet, D., Dillenbourg, P.: Perceiving learning at a glance: a systematic literature review of learning dashboard research (2017)
7. Jivet, I., Scheffel, M., Drachsler, H., Specht, M.: License to evaluate: preparing learning analytics dashboards for the educational practice. In: Learning Analytics & Knowledge Conference (2018)
8. Alonso-Fernandez, C., Calvo, A., Freire, M., Martinez-Ortiz, I., Fernandez-Manjon, B.: Systematizing game learning analytics for serious games. In: 2017 IEEE Global Engineering Education Conference (EDUCON) (2017)
9. Perez-Colado, I.J., Alonso-Fernández, C., Freire-Moran, M., Martinez-Ortiz, I., Fernández-Manjón, B.: Game learning analytics is not *informagic*! In: 2018 IEEE Global Engineering Education Conference (EDUCON) (2018)
10. Serrano-Laguna, Á., Martínez-Ortiz, I., Haag, J., Regan, D., Johnson, A., Fernández-Manjón, B.: Applying standards to systematize learning analytics in serious games. Comput. Stand. Interfaces **50**, 116–123 (2017)
11. Calvo-Morata, A., Fernández-Manjón, B.: Conectado: concienciando contra el cyberbullying mediante un videojuego educativo. DIM Didáctica, Innovación y Multimedia (2018)
12. Verbert, K., Duval, E., Klerkx, J., Govaerts, S., Santos, J.L.: Learning analytics dashboard applications. Am. Behav. Sci. **57**, 1500–1509 (2013)

Learning Content Management and Experience Sharing

Authoring Adaptive Digital Computational Thinking Lessons Using vTutor for Web-Based Learning

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Abstract. Teaching style and personalized content delivery may have a significant impact on learning. While personalization for learners takes center stage in many research efforts, the same is not so true for teaching. A critical step in teaching is designing effective and customizable lesson plans using best-practices. In this paper, we present a web-based lesson plan design tool, called *vTutor*, that is designed keeping personalization for teachers in mind. We present and discuss content authoring using vTutor for web-based computational thinking classes.

Keywords: Digital content authoring · Web-based learning · Multi-media documents · Web interface · Computational thinking

1 Introduction

The quest for an intelligent tutoring system able to mimic human instruction is not new. However, it remains an open problem even though several smart systems such as AutoTutor [11], DeepTutor [15], and Oscar [9] are making progress. Some of these systems have started using novel techniques to improve learners' experiences. For example, Hendrix [6] tries to understand an e-learner's subject comprehension by classifying the learners' facial images, and Oscar [4] uses learning style prediction to personalize teaching; both of these projects adapt tutoring strategies dynamically as the tutoring sessions progress. Speech technology [17], animation and simulations [5], blended tutoring and real-time assessment [13] are being assimilated into intelligent tutoring systems moving toward creating ever smarter online robotic tutors, called a *conversational intelligent tutoring*

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system (CITS). This paper presents a new model of CITS using computational thinking instruction delivered over the web.

We discuss a content authoring tool for web based programming classes, called the *vTutor*, that is equally effective for institutional and free-choice learners. While the system is currently under development, we present the model that is driving its development and discuss several component systems that we have already experimented with. The discussion presents a coherent view of the vTutor system and allows the readers to appreciate the vision of the system. We discuss four components in particular - (i) the model, (ii) the user interface, (iii) the MindReader [7] code repository, and (iv) ad hoc computer program composition for tutoring. We avoid the technical underpinnings in the interest of space. Instead, we discuss the process on intuitive grounds using a bubble sorting example in C++ as shown in Fig. 1.

```
 3: int main() {
 4: int n = 4, ar[5]={100,-2,5,12,-445},
        i, j, temp;
 5: for (i = (n - 1); i >= 0; i--) {
 6:   for (j = 1; j <= i+1; j++) {
 7:     if (ar[j-1] > ar[j]) {
 8:       temp = ar[j-1];
 9:       ar[j-1] = ar[j];
10:       ar[j] = temp; }  }  }
11: for (i=0; i<=n; i++)
12:   cout << ar[i] << "!\n"; }
```

(a) Using nested backward counter loops.

```
 4’:  bool flag=true;
 5*:  while (flag)  {
 5’:    flag=false;
 6*:    for (j = 0; j <= n-1; j++) {
 7*:      if (ar[j] > ar[j+1]) {
 8*:        temp = ar[j];
 9*:        ar[j] = ar[j+1];
10*:        ar[j+1] = temp;
10’:        flag=true; } }  }
```

(b) Better implementation using `while`.

Fig. 1. Bubble sort code segments in C++.

The code segment in Fig. 1(a) can also be used to introduce variable types and their initialization (statement 4), iterations (statements 5, 6 and 11), conditionals (statement 7) and console I/O (statement 12). This is also a very good example to discuss nested iterations (statements 5 and 6), backward loops (statement 5) and functionally equivalent statements, when we replace the code segments as shown in Fig. 1(b) (primed lines are new, and starred lines are replaced). In the next several sections, we highlight how a virtual lecture will be designed in vTutor, and how online learners will learn bubble sorting using its conversational style intelligent interface in natural English. In particular, we discuss how a learners' probing questions prompt vTutor to compose responses from the MindReader code base.

2 A Tour of vTutor

While vTutor leverages the MindReader system for assessment and tutoring content, it is distinct and aims to serve as a virtual instructor for delivering interactive lectures in a conversational style. vTutor's approach to lesson delivery begins with a prepared lecture plan. The lecture plan is designed by a human instructor keeping in mind that remote learners may interrupt, ask questions, steer vTutor in a different direction or force it to rethink the content being covered because the learner is unable to follow the content or finds the content not challenging. The next few sections describe how a vTutor lecture is planned and designed, how it is delivered and how learners interact with it to receive the lessons.

2.1 vTutor User Interface

The vTutor user interface is the front-end through which teachers design autonomous multi-media lectures and through which learners access these lectures. The interface thus supports two views of the vTutor database, and assembles various tools to help educators and learners use the database in meaningful ways. We introduce the vTutor interface in the context of the bubble sort lecture example in Fig. 1.

The Learner View. The vTutor interface in Fig. 2 depicts a distance learner that has selected the lecture on bubble sorting from the learner's dashboard (not shown). The learner dashboard has, among other functions, an option to find and schedule a series of lectures that are aligned with his learning objectives. The series of lectures are presented based on relevance, overall lecture flow, and of course, dependency. Depending on the objectives of the learner, the series may contain formative and summative assessments for each of the lectures, conditional migration from module to module, and overall assessment of a subject represented in the series of lectures.

As shown in Fig. 2, learners are presented with a multi-modal web based interface that basically consists of four main frames – (1) the blue **system frame** in which vTutor presents computer programs for discussion, illustration, animation or execution while a voice narration can be superimposed. This frame is used by the system as a traditional classroom white board. (2) the green user **interaction frame** in which the learner writes computer code segments for the vTutor system either in response to a vTutor question, or to ask a question. (3) the white **output frame** at the bottom in which vTutor writes compiler error messages, outputs of program executions, diagnostic messages, and evaluation of a programming task in the form of comments. Finally, (4) the grey frame is used as a **chat window** between the learner and the vTutor system. Similar to many popular chat systems, vTutor is capable of accepting voice input by activating the mic at the top right corner above the chat window. Similarly, audio instructions can be enabled for vTutor in chat so that vTutor can use both text and audio to chat with the learner. The default audio voice can be selected from a voice bank as part of user profiles and overridden for a specific presentation. The lecture presentation bar at the top shows the progress of a presentation, and can be rewound, resumed, advanced or repeated in ways similar to any multi-media presentations such as YouTube. The rewind does not rewind the chat window.

Figure 2 shows a lecture on bubble sort using the code in Fig. 1(a) until it progressed to the discussion of the first `for` loop, when the learner asked the

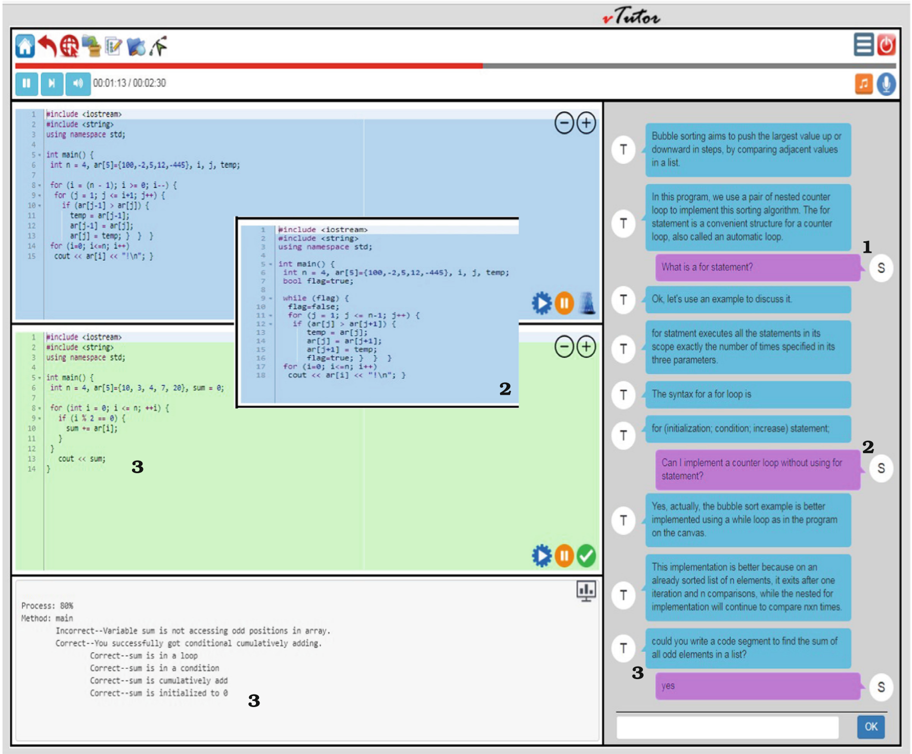

Fig. 2. Learner view of vTutor

question in bubble marked 1 in the chat window about the `for` loop. At that point, vTutor moved to retrieve the lecture on general `for` loop and discuss it, which is shown in Fig. 3 being designed by an instructor (discussed in detail in the next section). In this context, it would be instructive, relevant and perhaps necessary for vTutor to discuss the similarity and difference between the forward `for` loop lecture it just presented, and the backward `for` loop used in the bubble sort code segment being used in the lecture. The need for such *graceful transitions* in vTutor can be determined by vTutor by asking assessment questions, e.g., on `for` loop, after a lecture snippet is presented on a topic.

Bubble 2 asks whether there are alternative coding styles for a loop, perhaps because the learner did not quite understand the semantics of the `for` loop, also known as counter loop. At this stage, vTutor points out that yes, it can also be written using a `while` loop and rewrites the code segment using the statements in Fig. 1(b), and remarks that this version of the bubble sort has a better average and best case performance. Such nuanced remarks can only be made if a clever comparison between code snippets can be made using their execution behavior. In vTutor, such annotations are made by the community using a crowdsourcing approach. In fact, MindReader code snippets are stored in a public repository where the programming community annotates these snippets based on their membership in the lattice $\mathcal{L}$, and the set of labels L.

The white output frame at the bottom shows the comments and diagnostic messages vTutor made on the code segment the learner wrote in the green frame in response to vTutor's assessment question in bubble 3 in the chat window. Depending on the design of the lecture in progress, vTutor may ask follow up questions or prodding comments if it determines that there still remains diagnostic deficiencies in the student's level of comprehension.

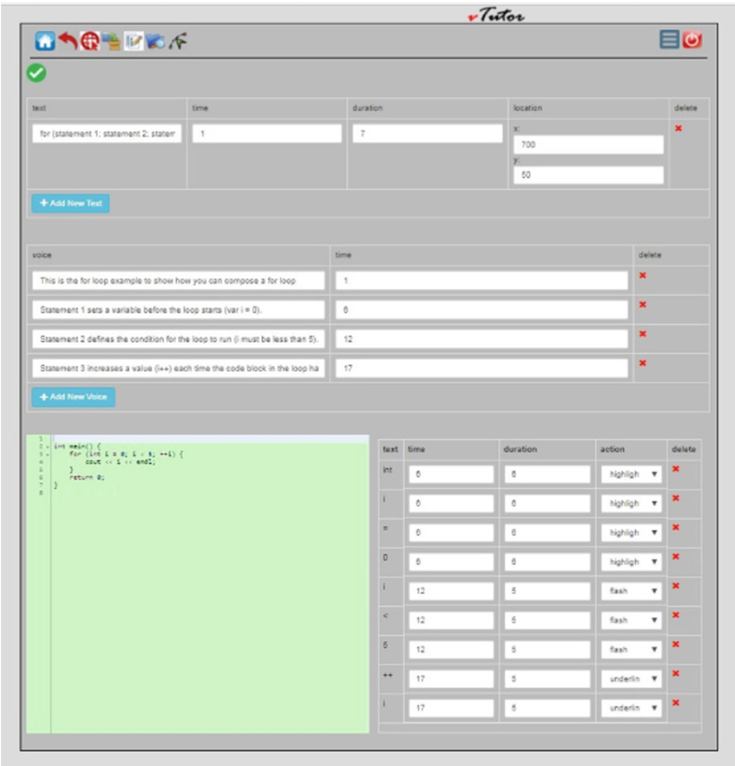

Fig. 3. Instructor or lecture designer view of vTutor

The Instructor View. The instructor dashboard for creating a lecture is shown in Fig. 3 in which she is developing the lecture that describes the construction and semantics of the `for` loop that we have discussed in Sect. 2.1, in relation to the chat bubble 1. For this lecture, she used a voice over, and animated text segments in the code that respectively highlights, flashes and underlines the three parameters of the `for` statement while describing the syntax in audio. The text for the audio is included, and the timing is synchronized with the text and animation that need to be displayed.

3 Related Research

Autonomous teaching and tutoring of computational thinking has been a long-standing goal for researchers [1]. With the emergence of the internet and the push for web-based instruction, this research has gathered renewed urgency [2], and it was shown recently that large scale tutoring is possible by designing intelligent user interfaces. Earlier research also emphasized the use of natural language for CITS [8]. While question answering from lecture videos has been attempted using automated annotation [14], technical questions such as *"how do I write a while loop that is functionally equivalent to a for loop"* could not be answered. In JavaTutor [16], attempts were made to recognize learner reactions and adapt tutoring steps. The tables were turned in [10] where learners were asked questions to help assess their cognitive state skill level.

In contrast to many notable approaches in this active area of research, vTutor utilizes automated program synthesis [3] based tutoring responding to learners' questions during an automated conversation enabled lecture. While in vTutor, the lecture snippets are pre-designed and static, the lectures used to respond to queries are fully automatically conceived and composed. This departure makes vTutor unique and significantly more powerful and effective. In ongoing research, we have been successful in manually synthesizing larger code fragments from elementary and arbitrary code segments from the MindReader database. It was also shown that semantic descriptions can be used to construct programs from components in MindReader. These technologies make it possible to synthesize lectures from components dynamically, in sharp contrast to contemporary techniques.

4 Conclusions

Petrov et al. [12] note that using synthesis of digital multi-media learning assets and learning objects for teaching is not new. However, the contemporary CITS are not well developed to synthesize responses for complex subjects such as computer programming courses, especially framing responses based on the depth of comprehension of the learners. In this paper, we presented a comprehensive model for the learning material authoring system vTutor that includes some of the properties Petrov et al. recommend, and extends the model with animation, conversation, question answering by automated lecture synthesis, and assessment, all with interactive system support over the web. Although we are in the early stages of our research, continuing to develop several components, it is easy to see that our lecture authoring, response synthesis model and system architecture are novel and likely unprecedented.

References

1. Anderson, J.R., Skwarecki, E.: The automated tutoring of introductory computer programming. Commun. ACM **29**(9), 842–849 (1986)

2. Butz, C.J., Hua, S., Maguire, R.B.: A web-based bayesian intelligent tutoring system for computer programming. Web Intell. Agent Syst. **4**(1), 77–97 (2006)
3. Chadha, S., Byalik, A., Tilevich, E., Rozovskaya, A.: Facilitating the development of cross-platform software via automated code synthesis from web-based programming resources. Comput. Lang. Syst. Struct. **48**, 3–19 (2017)
4. Crockett, K.A., Latham, A., Whitton, N.: On predicting learning styles in conversational intelligent tutoring systems using fuzzy decision trees. Int. J. Hum.-Comput. Stud. **97**, 98–115 (2017)
5. Fang, N., Tajvidi, M.: The effects of computer simulation and animation (CSA) on students' cognitive processes: a comparative case study in an undergraduate engineering course. J. Comput. Assist. Learn. **34**(1), 71–83 (2018)
6. Holmes, M., Latham, A., Crockett, K., O'Shea, J.D.: Modelling e-learner comprehension within a conversational intelligent tutoring system. In: Tatnall, A., Webb, M. (eds.) WCCE 2017. IAICT, vol. 515, pp. 251–260. Springer, Cham (2017). https://doi.org/10.1007/978-3-319-74310-3_27
7. Jamil, H.M.: Automated personalized assessment of computational thinking MOOC assignments. In: IEEE ICALT, Timisoara, Romania, 3–7 July, pp. 261–263 (2017)
8. Lane, H.C., VanLehn, K.: Teaching the tacit knowledge of programming to novices with natural language tutoring. Comput. Sci. Educ. **15**(3), 183–201 (2005)
9. Latham, A., Crockett, K.A., McLean, D.: An adaptation algorithm for an intelligent natural language tutoring system. Comput. Educ. **71**, 97–110 (2014)
10. Nakajima, H., Takahashi, N., Hosokawa, Y.: A QA cycle for teaching programming. A mechanism for automatically posing questions corresponding to learner's skill. Syst. Comput. Jpn. **38**(1), 28–40 (2007)
11. Nye, B.D., Graesser, A.C., Hu, X.: AutoTutor and family: a review of 17 years of natural language tutoring. AI Educ. **24**(4), 427–469 (2014)
12. Petrov, M., Asenov, A., Aleksieva-Petrova, A.: Software server for automatic generation of audio lectures (uListenSrv). Int. J. Adv. Corp. Learn. **10**(1), 55–74 (2017)
13. Razzaq, L.M., et al.: A web-based authoring tool for intelligent tutors: blending assessment and instructional assistance. In: Nedjah, N., Mourelle, L.M., Borges, M.N., Almeida, N.N. (eds.) Intelligent Educational Machines. Studies in Computational Intelligence, vol. 44, pp. 23–49. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-44921-8_2
14. Repp, S., Linckels, S., Meinel, C.: Question answering from lecture videos based on an automatic semantic annotation. In: ITiCSE, Madrid, Spain, 30 June–2 July 2008, pp. 17–21 (2008)
15. Rus, V., Niraula, N.B., Banjade, R.: DeepTutor: an effective, online intelligent tutoring system that promotes deep learning. In: AAAI Conference on Artificial Intelligence, 25–30 January 2015, Austin, Texas, USA, pp. 4294–4295 (2015)
16. Wiggins, J.B., Boyer, K.E., Baikadi, A., Ezen-Can, A., Grafsgaard, J.F., Ha, E., Lester, J.C., Mitchell, C.M., Wiebe, E.N.: JavaTutor: an intelligent tutoring system that adapts to cognitive and affective states during computer programming. In: SIGCSE, Kansas City, MO, USA, 4–7 March 2015, p. 599 (2015)
17. Wolff, S., Brechmann, A.: MOTI: a motivational prosody corpus for speech-based tutorial systems. In: ITG Conference on Speech Communication, pp. 1–4. IEEE (2012)

Effects of Introducing a Game-Based Student Response System into a Flipped, Person-Centered Classroom on Object-Oriented Design

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Abstract. Gamification and flipped classrooms are popular concepts in the educational sector, especially in engineering education. We introduced the gamified student response system Kahoot! to a flipped undergraduate computer science course on object-oriented design. The 25 students took part in interactive quizzes during class. Data was collected from nine quizzes consisting of 227 questions, six surveys, as well as a final course feedback.

The students experienced a higher learning effect, were more motivated, would like to have more face-to-face lessons with a quiz, and were overall satisfied with the quizzes. A significant correlation between quiz performance and grades on the exam, which tested higher-level competencies, was proven. The grades for the exercises and the exam showed a direct relationship in a homogenous linear regression. The overall course feedback and grades were improved. Evidence therefore suggests that gamified student response systems may improve student engagement, motivation, and learning effect in flipped classrooms.

Keywords: Gamification · Flipped classrooms
Person-centered learning · Kahoot! · Object-oriented design
Engineering education

1 Introduction

Although the term gamification might be relatively new, the concept of using game mechanics to solve problems and engage audiences has been used for hundreds of years [1, p. ix]. In general, gamification can be defined as the "application of game design principles and mechanics to non-game environments" [2,

G. Hancke et al. (Eds.): ICWL 2018, LNCS 11007, pp. 132–139, 2018.
https://doi.org/10.1007/978-3-319-96565-9_13

p. 8]. Studies predict a growth of the gamification market size [3,4], including the educational sector [5].

As a result, the use of gamification in the classroom to engage students is being currently practiced and researched by educators around the globe [6–11]. Chaiyo and Nokham compared the effect on different factors of learning of three different classroom response systems: Google forms, Quiziz and Kahoot! [12]. Their research showed that students taking part in Kahoot! or Quiziz quizzes reported a significantly higher concentration, student engagement, motivation and satisfaction than students using Google forms. Moreover, it helped the students to keep track of their learning process. Self-evaluation is also an important aspect in person-centered learning. Carl Rogers, who is considered the originator of the person-centered approach based on his work in person-centered therapy [13], wrote: “The evaluation of one’s own learning is one of the major means by which self-initiated learning becomes also responsible learning” [14, p. 158]. The positive effects of person-centered learning have been described by Freiberg, who extended Rogers’ research [15].

Derntl et al. applied peer- and self-evaluation to a web engineering and project management course using a blended learning concept [16] and concluded that self-evaluation provides a way of fostering self-reflection and creates transparency of grading. Flipped classrooms also use blended learning: students study new content at home, so that questions can be answered in class and the face-to-face time can be used to practice or to do lab activities [17]. Kanelopoulos et al. performed an extensive literature review and identified an increasing trend of flipping the classroom in engineering classes in order to engage students [18]. Tsai et al. combined the concepts of flipped classrooms and gamification by introducing the game-based student response system Kahoot! into a flipped seminar course [19]. A significant increase in learning interest, learning attitude and interaction could be measured. Standl developed a framework of design patterns for person-centered computer science education and included the self-check as a person-centered method [20]. The main goal of this method is to enable students to acquire self-reflective competencies. However, the focus of Standl’s self-check was on project assessments, raising the question whether the self-check method is also a viable option for regular assignments.

This paper analyzes the applicability of the game-based student response system Kahoot! to an object-oriented design course in a flipped classroom setting and its connection to the person-centered approach. In detail, it deals with the following research questions: 1. “Can the self-check method that stems from person-centered learning be reasonably implemented using a game-based student response system?”, 2. “Does the gamified approach bring additional value to a flipped classroom?”, 3. “What is a reasonable number of face-to-face lessons utilizing a game-based student response system?”, and 4. “Do the effects wear off over time?”.

2 Methodology

To answer these questions, an undergraduate computer science course introducing students to the principles of object oriented design was reorganized and evaluated in 2017. As the course is part of a part-time bachelor's degree program, it uses a flipped classroom setting, granting students the flexibility to study the class content independently of time and location. Three modifications have been introduced to the course: First, instead of a block schedule, in which the course was completed within 9 weeks, the course was stretched over the whole semester, allowing more flexibility. Second, the students had two 45-min units per week instead of a block of four units. Third, the lessons repeating the new content were enriched with gamified quizzes using Kahoot!.

To measure the effect of the introduced changes, the following aspects have been evaluated with the friendly permission of the students: *1. Surveys.* Six voluntary, anonymous surveys were conducted right after a quiz was completed, asking students to rate their level of agreement on several statements. *2. Course feedback.* After the exam, the students were asked to give a final overall course feedback consisting of nine standardized rating questions about the course. *3. Performance.* The students' performance was measured by their scores on the exercises, quizzes, as well as the final exam. Throughout the semester, nine interactive quizzes were conducted in class with a total of 227 questions including four answers, one of which was correct.

3 Results

3.1 Survey

Table 1 shows the percentage of students (rather) agreeing with the presented statement of the anonymous survey over time. Quizzes 4 and 5 have been evaluated by the same survey as they were conducted in the same unit.

The feedback on the quiz comprehensibility remained positive over time: more than 89% of all students agreed or rather agreed with this statement in every iteration with an overall average of 96%. The difficulty seemed to be fair: one student reported that he or she liked the "partially tricky questions"[1]. The questions were designed to be of practical nature and included many images which showed a UML diagram and prompted students to identify certain facts.

More than 89% of all students (rather) agreed in each iteration that they learned something through the quiz questions, the overall average agreement is 94%. One student wrote a longer comment: "I really like that you can concentrate on the questions because of the short time, making you try to answer them correctly. If you pick the wrong answer, you get a very detailed explanation which helps you understand [the matter better]. Thank you for this great opportunity. I would appreciate it if the course keeps those quizzes."

[1] The rating scales, feedback questions, and students' quotes have been translated from German.

Table 1. Percentage of students agreeing or rather agreeing with presented statement

	Quiz					
Statement	Q3 N = 18	Q4-5 N = 15	Q6 N = 14	Q7 N = 13	Q8 N = 9	Q9 N = 11
The questions of the quiz were formulated in a comprehensible manner	100%	93%	93%	100%	89%	100%
I have learned something new in today's class	100%	93%	93%	100%	89%	91%
Due to the quiz, I was more engaged in the learning process than usual	89%	87%	93%	85%	78%	100%
The quiz motivated me to self-study more than an oral in-class repetition	94%	67%	93%	92%	89%	91%
Overall, I am satisfied with today's quiz	100%	87%	86%	100%	89%	91%
I would like to recapitulate the next chapter using a quiz as well	100%	93%	93%	100%	89%	100%

This comment was one of the reasons we kept designing new quizzes. It showed that students really appreciated them and that the effort of creating the quizzes paid off. Other written feedback of students on what they liked about the learning effect included: "Having fun and learning something at the same time", "Studying with fun", "You learn a lot with Kahoot!. That is really great", "A playful way to study... Great!", "Certainly, a good tool for learning", "You simply remember more", and "You learn a lot".

Over all iterations, at least 78% of students agreed or rather agreed that the quiz made them engage more actively in the learning process. The average of all iterations is 88%. This suggests that not only did the Kahoot! quizzes promote the learning effect, but also increased student engagement. Verbal feedback on what the students liked about their engagement included: "Everyone can take part", "Interactive participation for everyone", and "Everybody takes part".

More than 67% of students (rather) rather agreed that the quiz motivated them to self-study more than an oral in-class repetition in each iteration. The average over all iterations was 88%, which suggests that the quizzes are a viable and possibly better alternative to an oral in-class repetition. Positive remarks on the students' motivation included: "The whole concept of no grading but competition is fun and useful", "Positive effect on students", "An incentive because of competition", "Very motivating", and "A very good self-check for study".

At least 86% of all students stated that they were (rather) satisfied in each iteration with a total average of 92%. The overall satisfaction did not notably drop over time, which indicates that the positive effects of Kahoot! quizzes do not wear off. A student's comment in the middle of the course was "It is perfect as it is now... Thank you!" Another student said that the regular quizzes on Friday were the one thing that he or she was looking forward to.

If a recurring outlier with a possible inverted scale is not taken into consideration, 100% of the students agreed or rather agreed in all iterations that they wanted to keep the quizzes as a regular element of the face-to-face classes.

Finally, the students were asked for their preferred number of units employing a quiz: 0%, 25%, 50%, 75% or 100%. The actual number of units with a quiz was 7 out of 16. This means that the answer "50%" reflected the actual situation best. Only one student stated once that he or she would like to have fewer quizzes. Each iteration showed that at least 64% of all students wished to have more quizzes in class with an overall average of 73%. The overall mean preferred number of units employing a quiz is about 80%.

3.2 Course Feedback

A final anonymous and voluntary course feedback consisting of nine standardized statements was collected in the last unit in 2016 and 2017. The students rated their agreement with these statements on a scale from 1 (disagree) to 4 (agree). For simpler comparison, the data was treated as interval data.

The overall evaluation of the course in 2017, which employed quizzes, was notably more positive. The biggest difference was measured in the reported student engagement: the mean level of agreement increased from 2.9 to 3.6. This difference was found to be significant in a two-tailed t-test with p = 0.008. This again supports the thesis of a higher student engagement in the learning process. The course material was also rated notably better in 2017, rising from 3.2 to 3.8. This difference was also found significant with p = 0.013, showing that the students see the quizzes as a reasonable learning aid.

3.3 Performance

To evaluate the influence of quizzes and exercises on the learning effect, the scores on the quizzes, exercises and the final exam have been analyzed. A correlation analysis using Pearson's correlation [21] revealed a significant strong correlation between quiz score and score on the exam with $r = 0.71$ ($p = 6.6 * 10^{-4}$), indicating that the quizzes are a good preparation for the exam. A similar correlation could be observed between the total number of correct answers on all quizzes and the score on the exam with $r = 0.70$ ($p = 9.1 * 10^{-4}$). The estimate for the coefficient in a homogenous linear regression is 1.3 ($p = 1.9 * 10^{-14}$), which means that, on average, one correct answer on a quiz was worth 1.3 points on the exam. The best possible grade on the exam was 192 points. Although the quiz questions are simple single choice questions, the fact that a student manages to respond correctly to simple questions appears to predict improved performance on higher-level design tasks that were tested in the exam.

An analysis of the correlation between the total score on the exercises and the exam revealed $r = 0.52$ ($p = 0.023$). The homogenous linear regression analysis returned a coefficient of 0.98 ($p = 2.2 * 10^{-16}$), which means that about one point on the exercises is worth one point on the exam. As the highest possible score on the exercises was 192 and the highest possible number of correct answers was 227, it seems that the number of correct answers on the Kahoot! quizzes was an even better indicator for the exam grade than the exercises.

4 Conclusion

We analyzed the effects of the gamified student response system Kahoot! on several factors of learning. The research questions can be answered as follows:

1. Yes. Although the analyzed student response system only allows multiple-choice questions, it seems that higher-level competencies can also be strengthened if multiple-choice questions are used correctly.
2. Yes. Students reported higher engagement, learning effect, motivation, and satisfaction. A connection between quiz and exam performance was observed.
3. We analyzed the effects of quizzes in about 50% of all face-to-face units. The students reported that they would have liked more quizzes in class. On average, they would like to have about 80% of all units utilizing a quiz.
4. No, within the time-frame of one semester they do not seem to wear off. There was no notable drop of the analyzed factors over time.

Overall, gamified student response systems proved a viable method for flipped classrooms to promote person-centered learning. Gamified student response systems offer an opportunity to facilitate student engagement. Despite the clear findings, we are aware of several limitations of this study, most prominently the small sample size, the fact that the case was studied with one teacher only who taught the two classes in sequence, multiple changed variables, and the duration of the study being just one term. We will further investigate the adoption of student response systems in class as a method of person-centered learning.

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References

1. Zichermann, G., Cunningham, C.: Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. O'Reilly Series. O'Reilly Media, Sebastopol (2011)
2. Kumar, J.M., Herger, M.: Gamification at Work: Designing Engaging Business Software. The Interaction Design Foundation, Aarhus (2017)

3. P&S Market Research: Gamification market, January 2016. https://www.psmarketresearch.com/market-analysis/gamification-market. Accessed 5 Jan 2017
4. MarketsandMarkets Research: Gamification market by solution & applications type, January 2016. https://www.marketsandmarkets.com/Market-Reports/gamification-market-991.html. Accessed 5 Jan 2017
5. Banville, L.: Education gamification markets expected to grow globally, January 2016. http://www.gamesandlearning.org/2016/12/14/gamification-elements-continue-to-draw-dollars/. Accessed 5 Jan 2017
6. de Almeida Souza, M.R., Constantino, K., Veado, L., Figueiredo, E.: Gamification in software engineering education: an empirical study. In: 2017 IEEE 30th Conference on Software Engineering Education and Training (CSEE&T), pp. 276–284. IEEE, Piscataway (2017)
7. Jianu, E.M., Vasilateanu, A.: Designing of an e-learning system using adaptivity and gamification. In: 2017 IEEE International Systems Engineering Symposium (ISSE), pp. 1–4. IEEE, Piscataway (2017)
8. Azmi, S., Iahad, N.A., Ahmad, N.: Attracting students' engagement in programming courses with gamification. In: 2016 IEEE Conference on e-Learning, e-Management and e-Services (IC3e), pp. 112–115. IEEE, Piscataway (2016)
9. Azmi, S., Ahmad, N., Iahad, N.A., Yusof, A.F.: Promoting students' engagement in learning programming through gamification in peer-review discussion forum. In: 2017 International Conference on Research and Innovation in Information Systems (ICRIIS), pp. 1–6. IEEE, Piscataway (2017)
10. Wang, A.I., Zhu, M., Sætre, R.: The effect of digitizing and gamifying quizzing in classrooms. In: 10th European Conference on Game Based Learning (ECGBL), pp. 729–737. Academic Conferences and Publishing International, Sonning Common (2016)
11. Wang, A.I., Lieberoth, A.: The effect of points and audio on concentration, engagement, enjoyment, learning, motivation, and classroom dynamics using Kahoot! In: 10th European Conference on Game Based Learning (ECGBL), 738–746. Academic Conferences and Publishing International, Sonning Common (2016)
12. Chaiyo, Y., Nokham, R.: The effect of Kahoot, Quizizz and Google forms on the student's perception in the classrooms response system. In: International Conference on Digital Arts, Media and Technology (ICDAMT), pp. 178–182. IEEE, Piscataway (2017)
13. Rogers, C.R.: A theory of therapy, personality and interpersonal relationships as developed in the client-centered framework. Psychol.: Study Sci. **3**, 184–256 (1959)
14. Rogers, C.R.: Freedom to Learn for the 80's, 2nd edn. Merrill Publishing, Columbus (1983)
15. Rogers, C.R., Freiberg, J.H.: Freedom to Learn, 3rd edn. Merrill Publishing, Columbus (1994)
16. Derntl, M., Motschnig-Pitrik, R., Figl, K.: Using teams, peer-and self evaluation in blended learning classes. In: Frontiers in Education 36th Annual Conference (FIE), pp. 15–20. IEEE, Piscataway (2006)
17. Bergmann, J., Sams, A.: Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education, Arlington (2012)
18. Kanelopoulos, J., Papanikolaou, K.A., Zalimidis, P.: Flipping the classroom to increase students' engagement and interaction in a mechanical engineering course on machine design. Int. J. Eng. Pedag. **7**(4), 19–34 (2017)
19. Tsai, H.H., Peng, J.Y., Chang, C.T., Yu, P.T., Chiou, K.C.: Applying an eBook tool with lecturing function and a game-based student response system in flipped

classroom for a seminar course. In: 2016 International Symposium on Educational Technology (ISET), pp. 75–79. IEEE, Piscataway (2016)
20. Standl, B.: Conceptual modeling and innovative implementation of person-centered computer science education at secondary school level. Ph.D. thesis, University of Vienna, Vienna, Austria (2013)
21. Pearson, K.: Note on regression and inheritance in the case of two parents. Proc. R. Soc. London **58**, 240–242 (1895)

A Semantic Graph-Based Japanese Vocabulary Learning Game

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Abstract. Study foreign languages in college level are sometimes offered as an academic minor. To achieve an academic minor, students have to enroll in selected subjects in specific field. Studying Japanese as an academic minor are offered at Chiang Mai University. The minor degree requires student to pass four classes of basic Japanese grammars and vocabulary including hiragana, katakana and kanji. The Japanese minor degree are designed for (more or less) equivalent to N5 level in Japanese Language Proficiency Test (JLPT).

In this work, Vocabulary matching game is developed to assist student vocabulary learning process. The game was designed as multi-stages, automatic generated MCQ game based on progression of the courses including matching between Japanese-Romanji, Japanese-Thai and Thai-Japanese. Vocabulary Semantic graph and frequently mistaken words were used to generate the question stem and plausible distractors using collaborative filtering technique.

Keywords: Game-based learning · Adaptive learning
Semantic graph · Multiple choice question generation

1 Introduction

Vocabulary learning is the most boring and time consuming part for student. In this work, we developed a vocabulary matching game to assist vocabulary learning process for novice level learners. The game was designed as Multiple Choice Question (MCQ) based on progression of the courses from basic to advance. Vocabulary ontology were built to represent semantic relationship among vocabulary. Semantic graph and frequently mistaken words were used to generate question stem and plausible distractors by using collaborative filtering technique. The questions and distractors from generation model were evaluated by Japanese instructor and minor degree students.

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The rest of the paper is organized as follows: Sect. 2 presents game concept and architecture. Section 3 describes the semantic graph-based MCQ generation including stem selection and distractor selection. Model evaluation and discussion are explained in Sect. 4 and the conclusion is in Sect. 5.

2 Game Concept

The target players of the game are students in Japanese language minor and any Japanese learner in novice level. The game is conceived as a mobile/web based multi-stage, multiple choice question game. Each stage has three sub-stages, from easy to hard level, containing 4-choices matching questions as Japanese-Thai and Thai-Japanese. The questions are auto-generated from lesson structure, predefined vocabulary semantic graph, and frequent mistake words from user statistic.

The Japanese Vocabulary Learning Game is composed of three parts: android/web game application, question generator service and statistical data analytic service. The system is developed using RESTful webservice architecture.

First, the android/web game interface, the game handles user local profile for anonymous mode and verify student user through university's Single Sign-On service. It will retrieve question list for each stage from Question Generator Service. The personal mistaken items is also used to personalize the question in next sub-stage. Question Generator Service generate a list of questions as per request from android game. The question list is composed of question stems and plausible distractors. The stems and distractors are selected from vocabulary semantic association graph by using collaborative filtering. The Statistical Data Analytic Service maintains game usage data and student profile for instructor to monitor individual student game activity and progress.

3 Automated MCQ Generation

The core function of the Vocabulary Learning Game is to automatically generate the reasonable questionsfte and choices. The objective of the vocabulary test is to measure the recognition of word form and meaning [4]. Traditional automate vocabulary MCQ generation used syntactic or lexical feature such as part of speech, prefix, suffix, derivation of words [1] which not reflect the meaning of the word in sufficient depth. Nation mentions the connection between word form and meaning [3].

Some of suggested memorization strategies involving semantic based are to group language material into meaningful units and using semantic mapping. Schimitt found that the vocabulary test in TOEFL not only measure lexical knowledge but also the meaning, word class, collocation and association among stem and distractors [6]. Yang and Dai conducted the research in foreign vocabulary memorizing strategies in Chinese students [7]. The questionnaire was conducted to review how the Chinese student prefer to used in memorizing English vocabulary, comparing between rote repetition, structural associations, semantic strategies, and mnemonic keyword technique. The result revealed that the most efficient technique were association and semantic based.

In this work, the vocabulary list from Japanese lesson were populated and vocabulary semantic graph were created by Japanese language expert. Then the collaborative filtering is applied to retrieve vocabulary in the similar context which indicated semantic related vocabulary. The list of semantic related vocabulary then were used as distractors in the automatic MCQ generation.

3.1 Vocabulary Semantic Graph Modeling

In order to create semantic relationship among terms, vocabulary graph was created. The graph was constructed based on two part of information, first, based information about lesson structure, and second the semantic enhancement of each term as depicted in Fig. 1.

The lesson structure contains relationship between game stages and book chapter and terms introduced in each chapter. From this first information, term with specific scope can be selected.

The semantic model describes both relationships among terms. The lexical information such as POS, homograph and synonym were retrieved from Japanese WordNet [2]. In order to express the associative and semantic into the graph, we capture the language expertise in how each term is used in specific context. One term can be used in multiple context so it can depicted in multiple relationship to different context. In this work, only one level of context is considered. The sub-class relationships between context are omitted.

Vocabulary were populated and semantic graph were modeled using Neo4j graph database, since Neo4j has scalability, flexibility in creating multiple relationship node, and well-defined query command-Cypher [5]. Cypher is a declarative, SQL-inspired language used for describing patterns in graphs.

3.2 Semantic-Based MCQ Generation

Generating multiple choice question has two steps, first is choosing stem or question, then selecting the distractors or other deceived choices. In this work, a weighed random function was used to select question stem. Then the stem was used to filter plausible distractors from semantic graph. The collaborative filtering technique was used. Vocabulary in the same or the closest context to the question were selected. The synonym of the question words were filtered out in order to avoid ambiguous choices.

The example of cypher command below was used to filter vocabulary which being used in the same context, but not being synonym, ranked by number of common context. The common context indicates semantic related vocabulary. The list of semantic related vocabulary were used to create plausible choices. From the example question in Fig. 2, car is a vehicle, the distraction are train bicycle and express train which are all transportation type. Student is a person in school context, all generated choices are also in school context, which normally considered as vocabulary memorizing strategies.

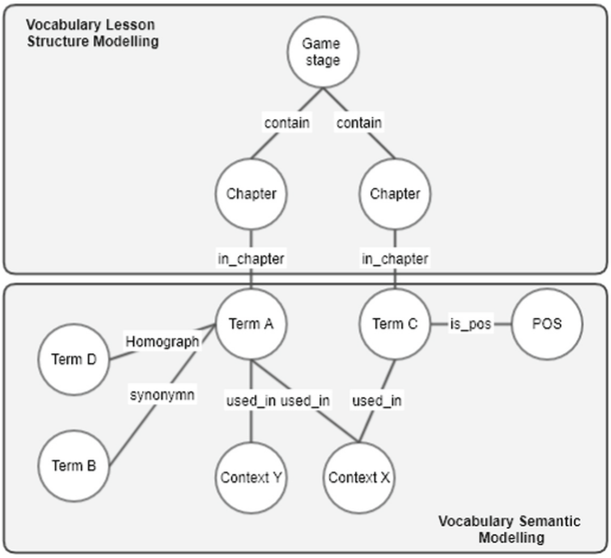

Fig. 1. Vocabulary graph modeling

Collaborative Filtering using Cypher Query

```
MATCH (n:Vocabulary)-[r:used_in]->(c:Context)<-[:used_in]-(p)
WITH n, p, count(c) as rels
WHERE n.vocabID = '"+id+"' AND NOT (n)-[:synonymn]-(p)
RETURN p.vocabID AS vocabID, p.hiragana AS hiragana ,
p.romanji AS romanji, p.thai AS thai, rels  ORDER BY rels DESC
```

くるま (car)

a. รถยนต์ **(car-[key])**
b. รถไฟ **(train)**
c. รถจักรยาน **(bicycle)**
d. รถไฟด่วน **(express train)**

นักเรียน, นักศึกษา (student)

a. かいしゃいん **(employee)**
b. せんせい **(teacher)**
c. がくせい **(student-[key])**
d. ともだち **(friend)**

Fig. 2. Example question generated with semantic based filtering

4 Evaluation and Discussion

The experiment was conducted to evaluate the reasonable of the generated question and distractors. The MCQ generation module was built by Python3.6 and

Neo4j version 3.3 with py2neo Neo4j driver version 3.1.2. Three hundreds vocabulary from 10 chapters were populated. Ninety-five contexts were modeled to classify semantic usage of vocabulary. 120 Hiragana-Thai and 120 Thai- Hiragana question sets were generated using 4 modes: randomly selected, lexical similarity, semantic similarity and lexical+semantic similarity. 30 questions from each mode are blindly mixed together in each question set. The question sets were evaluated by two N1 level Japanese instructors and 2 Japanese minor students who finished all requirement courses.

The experts were asked to answer two questions, adapted question from [1], about the generated questions: rate their difficulty and rate their usefulness of the choices. The difficulty level is defined as how to distinguish between the correct meaning of the stem and the distractor choices. There are 4 level of difficulty defined as: (1) very easy, (2) reasonable easy, (3) reasonable difficult, and (4) quite difficult. The usefulness of the question is determined by clearness of the choices, has exact one correct answer and not having redundant item choices. The level of usefulness can be classified as: (1) not useful because redundant choices, (2) not useful because ambiguous, (3) useful with broad relationship between choices and, (4) useful with close relationship between choices. The correlation coefficient among the expert opinion are 0.42 and 0.58 in difficulty and usefulness respectively indicated that their opinion are considered consensus.

The evaluation result of difficulty and the usefulness of the question are shown in Table 1. The question classified as reasonable easy and easy are considered as easy level, while reasonable difficult are classified as moderate level and quilt difficult question are interpreted as difficult level. The result shows that the questions generated with semantic consideration can bring about more difficult than only lexical applied.

Table 1. Average result of difficulty and usefulness level of generated questions in different modes

	Difficulty		
	Easy	Moderate	Difficult
0-Random	88.33%	11.67%	0%
1-Lexical	57.50%	37.50%	5.00%
2-Semantic	40.83%	55.00%	4.17%
3-Lexical+Semantic	35.00%	59.17%	5.83%
	Usefulness		
	Ambiguous	Less related choices	More related choices
0-Random	0%	65%	35%
1-Lexical	5%	45%	50%
2-Semantic	3.33%	11.66%	85%
3-Lexical+Semantic	1.67%	10%	88.33%

The usefulness of the question reflects the efficient of distractor choices and the correctness of the question/answer. The result shows that the semantic and the combination of lexical and semantic produce closer relation between choices than only lexical used.

The ambiguity of the question of each method can be explained as follow. Random method selected redundant words as choices, lexical selected different word with same or too close meaning. For the proposed semantic graph method, some words can replace with other words in some specific context, especially WH-question words, and prefix. These words were recommended by language instructor to be test in grammar quiz instead of vocabulary one.

5 Conclusion

Japanese Vocabulary Learning Game was designed as mobile application aim to assist student vocabulary learning process. The game was designed as Multiple Choice Question based on progression of the courses from basic to advance. Semantic graph were created to represent the relation between vocabulary and context. Collaborative filtering on semantic usage in different context were used in generating plausible choices for the question in the game. The evaluation from expert explained that the semantic-based question bring about more difficult questions than only lexical applied. These game can help learners in recognizing words and meaning. Our game will be applied and evaluated the effectiveness on self-learning process with Japanese minor student at Chiang Mai University on incoming semester.

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References

1. Alsubait, T., Parsia, B., Sattler, U.: Ontology-based multiple choice question generation. KI - Künstliche Intell. **30**(2), 183–188 (2016). https://doi.org/10.1007/s13218-015-0405-9
2. Isahara, H., Bond, F., Uchimoto, K., Utiyama, M., Kanzaki, K.: Development of Japanese WordNet. In: The 6th edition of the Language Resources and Evaluation Conference (LREC) (2008)
3. Nation, I.: Teaching & Learning Vocabulary. Cengage Learning, Inc., Boston (1990)
4. Ozturk, M.: Multiple-choice test items of foreign language vocabulary. Eğitim Fakültesi Dergisi **20**, 399–426 (2007)
5. Robinson, I., Webber, J., Eifrem, E.: Graph Databases. O'Reilly Media, Inc., Sebastopol (2013)
6. Schmitt, N.: The relationship between TOEFL vocabulary items and meaning, association, collocation and word-class knowledge. Lang. Test. **16**(2), 189–216 (1999). https://doi.org/10.1177/026553229901600204
7. Yang, W.-D., Dai, W.P.: Vocabulary memorizing strategies by Chinese university students. Int. Educ. Stud. **5**(1), 208–215 (2012)

Support for Overcoming Pedagogical Issues in Primary School Tablet-Based Classroom Environments

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Abstract. The objective of this study is to provide support for teachers to overcome the pedagogical issues that are evident in tablet teaching at primary schools in Thailand. The "Apps4Youth" web-based system is introduced as a practical tool to support teachers in the evaluation tablet-based educational applications. In the first part, the motivation for an evaluation tool is provided based on observations from two schools regularly using tablets in the classroom. The findings highlight pedagogical issues which lead to teachers' lack of confidence in adopting tablets at class, particularly in discovering applications, evaluating their applicability, and integrating with classroom activities. The second part of the study introduces a system that enables primary school teachers to evaluate their own classroom activities, share their experiences with other teachers, and search for classroom activities that could be applicable in their own context. The results of a survey, collected from 25 teachers, showed that teachers have positive and negative perceptions of the system and how it may improve support for teachers in the use of tablets in the classroom.

Keywords: Tablets · m-learning · Primary school · Technology acceptance

1 Introduction

Whether teachers like it or not, the use of mobile computational devices in the classroom is transforming classroom dynamics. Teacher reluctance in adopting mobile technology in the classroom often stems from a lack of confidence in applying it effectively – the fear that letting students use smartphones will descend into chaos. On the other hand however, forward-thinking teachers and educational technology researchers are suggesting mobile technology promises to transform teacher-centered instruction into learner-centered participatory learning [1, 2]. For this to happen, the teacher needs to be able to incorporate computing devices and their applications with their curriculum content and their own teaching styles [3]. This integrated use of computational devices is more challenging than simply playing an educational game or following an online course [4]. Many mobile applications can be helpful for delivering lessons and activities in class, but it is essential for the teacher to be in control of planning lessons, designing activities, teaching to the objectives, and guiding students through the class material [5]. At the same time, teachers would like to encourage

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students to express ideas, communicate with friends for exchanging knowledge, and share the accomplished tasks using technology [6, 7].

The reality in many schools, particularly in Thailand where the current study is undertaken, is that teachers are reluctant to make use of mobile technology in the classroom. Most studies point to teacher's lack of knowledge in the use and integration of newer digital devices into their classroom activities [7]. Some research has emphasized the need for teacher training as a necessary step to develop technology-based learning at schools [8]. Other issues are that schools lack funds to handle the equipment and to demonstrate to teachers and students the way to use rapidly-evolving digital devices. With this in mind, educationalists propose that mobile technology pedagogy should focus on building teachers' confidence through training and professional development [9].

In this study, the authors implement a system aimed at building teacher confidence on using tablet-based educational applications in the classroom. In contrast to formal training of teachers, the system emphasizes a community of practice approach [10] whereby the proposed web-based system can enable teachers to further their professional development through interaction with other practitioners.

2 Initial Analysis of Tablet-Based Teaching Issues

Tablets were chosen for their popularity at primary schools, due to the Thai education ministry undertaking "iClassroom" pilot studies in 50 schools nationwide [11]. These classrooms are equipped with iPads for all students and projection facilities for the teacher. In order to motivate the need to support teachers of tablet-based educational applications in Thai primary school classes, a small survey was undertaken. The survey was based on interactions with 6 primary level STEM teachers at Anuban Phitsanulok and Wat Yang schools over a period of 4 weeks. The teachers have less than one year experience in tablet-based teaching. They have attended training classes provided by the education ministry. The qualitative data collection drew on classroom observation and informal interview methods.

From the findings, most primary teachers are using a limited selection of applications suggested by the education ministry. Some teachers use only a small set of general applications, such as a word processor and a drawing application. Teachers commented that they usually do not have enough time to search and evaluate applications thoroughly before their class.

Another observation was that the pedagogy applied could vary between teachers significantly. It was not uncommon to find the tablets used as a replacement for notebooks as a way to enter the answers for electronic submission to the teacher. Alternatively, some English classes use the tablets as a way to listen and repeat or as a teaching aid only used by the teacher. There was one example from the observations where students were using Google Earth and YouTube and they got distracted from their tasks by looking at unrelated videos. None of these uses are what researchers have in mind when talking about the transformative aspects of technology in the classroom. As other researchers have noted, the proper technological resources and pedagogical practices are required for teachers to successfully integrate tablet at class [12].

There were examples where a certain use of an application in a particular environment appeared to make for an immersive educational experience for the students. There are many factors that could contribute to such 'successful' lesson. What worked for one level of students, might not work for another. An hour of tablet usage often didn't seem as successful as half of the time being spent on a warm up activity without the tablet. For example, when teaching animation, it was necessary to get the students to think about the steps in their animation first and do some planning before starting any drawing on the tablet.

The following eight issues summarize the difficulties faced by iClassroom teachers observed in the two schools:

1. *Variety of use*. Most primary level teachers are using a limited selection of applications and some teachers use only generic applications (e.g. Word).
2. *Discovery*. Many teachers do not know how to find appropriate applications that complement their classroom material.
3. *Preparation time*. Inexperienced teachers can spend considerably more time preparing for a tablet-enabled classroom activity.
4. *Integration*. The power of the technology relies on how well it can be applied to or complement existing classroom activities. Teachers lack experience in integrating technology with the curriculum.
5. *Suitability*. For inexperienced teachers it is not clear which pedagogical approaches are well supported by the use of tablets in the classroom.
6. *Dependence on technical ability*. Teacher's technical ability at using technology often determines the successful outcome of a classroom activity.
7. *Keeping students motivated*. The balance of application and its integration into class activities is critical to motivate and encourage active learning.
8. *Fear factor*. A bad experience teaching using tablets is likely to decrease teacher confidence and lead to resistance to technology in the classroom.

Overall, teacher confidence appears to be a critical factor when delivering tablet-based lesson and will be the key feature of a system to support teachers. This study introduces a system which is aimed at helping teachers to overcome the above issues.

3 A Web-Based Support System

Various models and frameworks exist to identify and analyze technology acceptance issues within an educational context. However, of those aimed at teachers, few are able to provide practical support for the pedagogical issues identified above. An exception is the Four Dimensional Framework (FDF) proposed by De Freitas [13], which is a tool for tutors to evaluate the use of game-based or simulation-based learning in practice. The framework proposes a checklist of questions that evaluates learning through four dimensions: context, learner specification, mode of representation, and processes of learning. The checklist makes FDF suitable for digitization and hence was chosen as the basis for a set of questions that a teacher could answer about a particular tablet app used in their class. The answers to the questions form an evaluation that is potentially valuable to other teachers engaged in tablet-based teaching exercises (e.g. through the discovery of new tablet activities or applications; in reducing preparation time; by giving examples of integration in classroom activities; by introducing appropriate pedagogical methods). Furthermore, a system that documents teacher evaluations is likely to give teachers confidence to change their use of tablets in the classroom (e.g. by reducing the technical burden of trying new activities; by having confidence that students will be engaged; or simply reducing the 'fear factor').

The implemented system, called "Apps4Youth", is a website open to teachers that provides three significant features: (a) search for applications by filtering subjects and levels; (b) read teachers' use and experience of the applications in specific contexts; and (c) contribute new evaluations of new or existing applications (as illustrated in Fig. 1). The website was implemented using the Laravel framework and a relational database. The backend of the website is able to connect to external APIs to retrieve information about the applications from the respective app store.

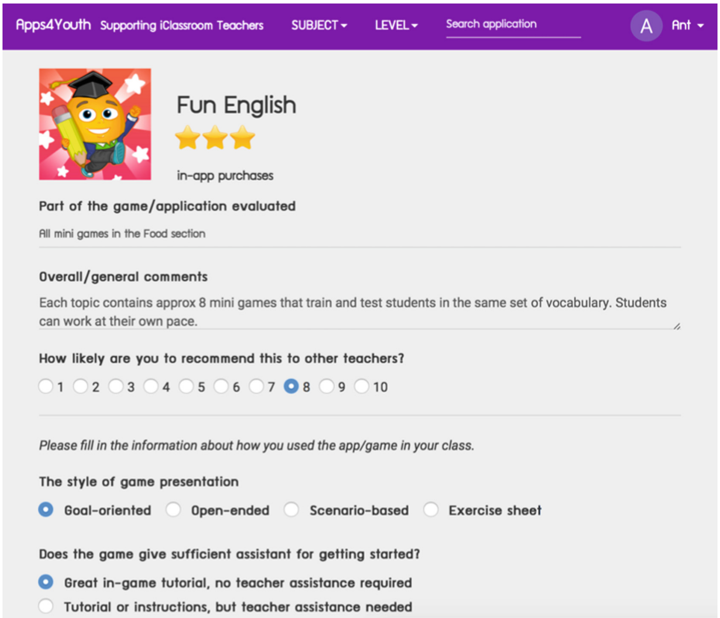

Fig. 1. The evaluation form to be completed by teachers

The evaluations are contributed by teachers by logging into the system and filling a form, part of which is shown in Fig. 1. The form was also available in Thai language. Teachers do not need to be familiar with FDF to complete the form. Each question was aligned with the 4 dimensions of the framework as described in Table 1.

Table 1. The questions in the evaluation form by dimension as per FDF

Dimension	Questions
1. Context	Type of classroom; number of students; technical requirements or extra equipment; number of tablets (per child, per group)
2. Learner specification	Level of study; student background knowledge of the subject
3. Mode of representation	Style of game presentation (goal-oriented vs open-ended vs scenario-based); skill/progress measurement (levels, time, score, none); time-dependence; rewards
4. Processes of learning	Level of scaffolding provided by the game; individual vs co-operative vs competitive; pedagogic approaches (problem solving vs quiz vs creative vs passive); expected learning outcome

4 Evaluation Method and Results

The Apps4Youth system was introduced at St. Nicholas International School and Wat Yang En School (Phitsanulok, Thailand) in November 2017. The participants were 25 primary school teachers who have experience of technology usage in STEM subjects. Following a workshop on the use of the system, the teachers were asked to use the system for a short period and then to complete a survey. Qualitative and quantitative data collection methods were used. The first part of the survey asks teachers to evaluate the system in terms of quality and content. The second part of the survey asks for the teachers' perceptions of the utility of the system. Only teacher perceptions of the system were collected – student perceptions were not considered because the system is designed for teachers (although students may benefit from classes where the teacher has used the Apps4Youth system).

Table 2 summarizes the responses on the quality of the system and its content. Some untruthful biased responses are found in the survey. This is because participants were endorsed by contradictory statements and standard deviation is quite high. *System quality*: The users agreed that system design is friendly and easy to search applications on their needs. The standard deviation and average scores in the statement 2 and 4 represents untruthful result. Similarly, statement 5, 6, and 7 got response biased because the standard deviation and average scores are high in all those statements. *Content quality*: Participants agreed the system provides sufficient information and helps them to get ideas for teaching activity. They get ideas by exploring system and reviewing overall description of an application. Teachers prefer to read comments than scores on an app. However, they did not agree the evaluation can help in lesson preparation, where the standard deviation has drawn above 1.00. It is an unreliable answer even the average is high.

The results of the perceptions part of the survey appeared to suggest that perceptions could be different depending on teaching experience and age. These perceptions are summarized by age and positive/negative in Table 3. In general, participants agreed that the system is able to provide a place for sharing knowledge on education applications can be used in the classroom. The system supports teachers in evaluating and providing the suitable applications from a mass of education applications. Some went

Table 2. Data analysis result of system evaluation

System quality	Avg	SD
1. It is easy to search apps for primary level	4.08	0.50
2. I felt frustrated while using the system	2.88	0.99
3. User interface design is clear and easy to understand	3.79	0.59
4. The system responds slowly	2.58	0.88
5. I would like to submit reviews again	3.50	0.83
6. Overall, I like to use the system	3.71	1.00
7. I would recommend this system to other teachers	3.75	0.90
Content quality		
8. The system provides sufficient information about each app	3.96	0.69
9. I can get ideas for classroom activities by using the system	3.92	0.72
10. It was difficult to insert a review	2.92	0.83
11. Reviews provide useful information	3.83	0.76
12. The teacher comments are more useful than the scores	3.71	0.75
13. Reviews can help me plan a lesson	3.67	1.01

as far as to say that the evaluated applications stored in the system would help them in persuading students in learning. They agreed that the system would make it easier to search for primary school level applications, which could make easier to understand difficult lessons for students.

Table 3. Teachers' perceptions on the Apps4Youth system

Experience	Positive perceptions	Negative perceptions
$\geq$ 15 years	Attractive UI design New knowledge in teaching	Slow loading speed Inaccurate evaluation form
11–15 years	Provide useful education apps User friendly and easy to access Can help to create a better teaching activity	Limited apps from specific play stores No description on class activity Limited information cannot support ideas for class use
3–5 years	Useful as teaching aid tools	Limited apps in each subject and level No description on class activity Limited availability of apps
$\leq$ 1 year	Easy to access Gain new knowledge on the trend of education	Evaluation form procedure is ambiguous

5 Discussion and Conclusion

The initial analysis has shown the extent to which primary school teachers are facing difficulties to integrate tablets in formal teaching activities. Of the eight difficulties highlighted in Sect. 2, teachers confirmed that the system can assist in overcoming problems relating to *variety of use (1)*, *discovery (2)* and *suitability (5)*. Some teachers said that they believed the system would help to keep *students motivated (7)* and improve their learning – although it would be difficult to quantify any improvement.

While the authors expected that the system would help teachers to have more *preparation time (3)* for tablet-based activity and reduce the time in finding suitable apps for class use, the teachers in the evaluation did not make any significant comments on this. It is difficult to find out if the system would be able to help teachers with *integration (4)* of tablet applications into the existing classroom activities – further experiments would need to monitor individual teachers in the preparation for their classes before any conclusions could be drawn. Similarly, a longer study would be needed to identify if teacher's *technical ability (6)* was improved and their *fear factor (8)* reduced through the use of the Apps4Youth system.

More likely is that the Apps4Youth system is only a partial solution to overcoming the issues. Teachers requested more human support and more guidelines in teaching with tablets until they have enough confidence. They were keen to learn about the possibilities of using tablets in the classroom, but many were reluctant to experiment themselves – more than anything else, the teachers are in need of a teacher.

The partial solution that the Apps4Youth system offers is as a mechanism for knowledge transfer: teachers can discover new applications and new classroom uses for applications, and they can read evaluations from their colleagues and other teachers. By following the dimensions of FDF, the system can help teachers compare contexts, learner specifications and learning processes. Further work is needed on the system to better communicate these features to teachers as this may increase confidence. It remains to be seen, as the body of evaluation knowledge increases, if such systems can give teachers confidence by seeing other teachers successfully organizing class activities around a particular context, learner specification and learning process.

References

1. Facer, K., et al.: Savannah: mobile gaming and learning? J. Comput. Assist. Learn. **20**(6), 399–409 (2004)
2. Valtonen, T.: An insight into collaborative learning with ICT: teachers' and students' perspectives. University of Eastern Finland (2011)
3. Anshari, M., et al.: Smartphones usage in the classrooms: learning aid or interference? Educ. Inf. Technol. **22**(6), 3063–3079 (2017)
4. Ally, M., Grimus, M., Ebner, M.: Preparing teachers for a mobile world, to improve access to education. Prospects **44**(1), 43–59 (2014)
5. Chu, H.-C., et al.: A two-tier test approach to developing location-aware mobile learning systems for natural science courses. Comput. Educ. **55**(4), 1618–1627 (2010)
6. Cribbs, J.D., Linder, S.M.: Bridging environments in the elementary classroom. Child. Educ. **91**(1), 41–45 (2015)
7. Antonioli, M., Blake, C., Sparks, K.: Augmented reality applications in education. J. Technol. Stud. 96–107 (2014)
8. Vosloo, S.: UNESCO, Policy Guidelines for Mobile Learning. UNESCO, Paris, France (2012)
9. Kukulska-Hulme, A.: Mobile learning for quality education and social inclusion (2010)
10. Lave, J., Wenger, E.: Communities of practice. Retr. June **9**, 2008 (1998)

11. *โครงการขยายผลการพัฒนาต้นแบบหลักสูตรการเรียนการสอนผ่านระบบเครือข่ายอินเทอร์เน็ต ตามหลักสูตรแกนกลาง สพฐ.* iClassroom. http://iclassroom.obec.go.th/
12. Montoya, J.Q., Rojas, G.D.H., Dussan, F.A.O.: Influence of digital tablets on the students' learning within a program strengthening teachers' pedagogical practices. In: 2016 International Conference on Interactive Mobile Communication, Technologies and Learning (IMCL). IEEE (2016)
13. De Freitas, S., Oliver, M.: How can exploratory learning with games and simulations within the curriculum be most effectively evaluated? Comput. Educ. **46**(3), 249–264 (2006)

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