Serious games for Information Literacy: assessing learning in the NAVIGATE Project⋆

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Abstract. Serious digital games can be a valuable tool for enhancing learning and have been used extensively for information literacy skills. However, there is no evidence that serious games improve learning as this is often superficially evaluated. The purpose of the paper is to understand how to improve the assessment of learning obtained with serious games. The NAVIGATE Project interdisciplinary team has tried to collaborate with university teachers to integrate the pedagogical aspect, the content aspect and the technological aspect and has produced two serious games named *The Navigator* and *The Information Trap Manager* that are described in their characteristics and limits. The paper also presents further research directions aimed at using Data Analytics to improve the effectiveness of game-based learning.

Keywords: Serious Games · Information Literacy · Learning Analytics · Learning assessment.

1 Introduction

A definition of serious games is still controversial. A first definition of serious games was formulated by [1] and stressed the purpose as a key factor of those games, within the integration in the learning process: "*we are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement.*" (in [1], p. 9). The intent, the educational purpose seems to be what makes a serious game. A second definition by [2] states that serious games "*have*

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more than just story, art, and software (...) They involve pedagogy: activities that educate or instruct, thereby imparting knowledge or skill". Even though the authors agree playing is always a serious matter, for our purposes we decided to focus on the pedagogical approach to serious games.

NAVIGATE - Information Literacy: A Game-based Learning Approach for Avoiding Fake Content is an European ERASMUS Project (2017-2020) which aimed to include games in the university teaching of humanities students, with the objectives of improving their information literacy (IL) learning. This project was based on existing approaches in partner countries, extending and exchanging skills on three different disciplinary aspects: pedagogical aspect, content aspect related to information literacy and technological aspect. The two Serious Games produced with the collective name NAVIGAME have created new learning paths specifically aimed at teachers and students of the humanities bachelor courses and are now in the test phase.

Although there is a large body of research on the subject of Game-Based Learning from a variety of disciplines, there are only a few in-depth tests in the classroom, which describe and evaluate their use in subject curricula and especially their impact on learning [3]. There is a growing understanding of students' motivational needs and the interactive skills of technologies, and there is more specific evidence of the benefits that gaming technology can have for students with special educational needs but not students in general. Thus, serious games continue to be full of promise but there is no evidence of improved learning. The NAVIGATE Project tried to focus on assessment and understand how it could be improved.

Acceptance of serious games and a new teaching strategy for IL

The teacher's experience and competence are particularly crucial. The teacher needs to understand the game in order to share and plan what students will need to do within their curriculum and be able to translate game progress into curriculum progress and learning outcomes to be achieved. The teacher must also be proficient in setting up game sessions in a limited amount of preparation time. Teachers also play the important role of anchoring game sessions as a learning activity, so they need to know how to contextualize game content in the curriculum being taught (or vice versa).

The process of a designed and then played game can also be used to assess student progress across the curriculum. The learning outcomes achieved through computer games largely depend on how we align learning (such as thematic areas of learning and learning purposes), learner characteristics and play-based pedagogy with the game design mechanics. In other words, if the objectives of the game match the objectives of the curriculum, the disconnections are avoided between game design and curricular objectives. However, there has often been a lack of collaboration between teachers and designers/developers of serious games and these are not embedded in the curriculum.

Students can play an important role in self-assessment of their learning. Students however tend to overestimate their skills (following the well-known Dun-

ning Kruger Effect [4]) and the student survey carried out at the beginning of the NAVIGATE project has also shown this. Games can help raise awareness of their digital skills and also stimulate them to provide constant attention to the problem.

Serious games are increasingly adopted for information literacy learning. It can be thought that any educational curriculum should encourage humanities students to discover, research, experiment, analyze, and reflect on the importance of information literacy. In some cases, serious games involve and motivate students in knowing how to evaluate fake content. NAVIGATE has started a collection of the best games that have been created for information literacy, producing a first registry in which they can be searched and rated, *The NAVIGAME Searcher* [5] The purpose of the paper is to understand how to improve the assessment of learning obtained with serious games. Games can be a platform for experimentation and interaction with something students wouldn't normally interact with. In the first produced NAVIGATE report "Game design template", the idea was to start mapping the parts of the search process where a game could play an important role for an entire class or for particular students. A game can also introduce a concept such as evaluation of resources to avoid fake content to the classroom and help students discover something interesting they want to know more of.

The paper is organized as follows. In section 2 the two NAVIGAME serious games are described. In section 3 we analyse the learning assessment model of the two serious games and its limitations. Section 4 outlines our work in progress to introduce game learning analytics for serious games to benefit the main stakeholders. Finally, some conclusive remarks and future extensions of our work are presented.

2   The NAVIGATE games

The two serious NAVIGATE games are the result of an interdisciplinary approach of an integrated team with complementary backgrounds. Partners collaborated on the NAVIGATE project by integrating multiple points of view, based on pedagogical theories, information literacy content and technological aspects, to create two different but coherent serious games to support and assess Information literacy skills of Higher Education humanities students.

2.1   Framing the games from a pedagogical model

Learning to solve problems and using higher order thinking skills are not the only types of instruction that occurs in the educational institutions. Students need to know facts, concepts, rules and procedures. These are all different types of knowledge related to information literacy and, therefore, each requires a different type of game design technique to effectively convey that knowledge. Although there is no single definition of the learning mechanisms of information literacy

(e.g. discovery, evaluation, experimentation), they represent a range of pedagogical intentions derived from the criteria of serious game pedagogy.

Declarative Knowledge is an association between two or more objects facts, jargon, and acronyms. It requires a content to be memorized. Elaboration, Organizing, Association, Repetition and the used gamification elements are: Stories/Narrative, Sorting, Matching, Replayability. *Conceptual Knowledge* is a grouping of similar or related ideas, events, or objects that have a common attribute or a set of common attributes. The used instructional strategies here are: Metaphoric devices, Examples and non-examples, Attribute classification in a combination with the following gamification elements: Matching and sorting, Experiencing the concept. *Rules-based knowledge* is a statement that expresses the relationships between concepts. Rules provide parameters dictating a preferred behavior with predictable results.The applied instructional strategies are: Provide examples and Role play and the used gamification elements is: Experience consequences. *Procedural knowledge* is a series of steps that must be followed in a particular order to reach a specific outcome (skills can be acquired by doing).

2.2 Framing the games from an information literacy model

According to [6], information literacy requires procedural skills that require complex levels of thinking and knowledge. The NAVIGATE games were framed within an information literacy model designed by the project in the first phase of its implementation. Before selecting particular game mechanics, an original Information Literacy framework (Competency Tree) based on the SCONUL standard was developed as an information literacy model to direct the flow of game action (Fig. 1).

The Competency Tree consists of 5 main areas related to Information Literacy and Avoidance of Fake Content each of them encompassing specific subareas. It reflects the information literacy outcomes based on the responses and performance of students from Bulgaria, Italy and Sweden. Taking into account the analysis of the learners needs based on the students reflections in the comparative survey and the evaluation of the existing information literacy games we have chosen the areas from the Competency Tree to prioritize on with the original NAVIGATE games. In the game design process, the alignment of game aims, mechanics and strategies, and content to be learned was an important principle to be followed by the NAVIGATE team. Another belief was that immersive gaming features should be used with care to avoid unnecessary cognitive load. The team also believed that educators should have a pivotal role in contextualizing the gaming experience. To integrate the gaming element into the educational process, it is above all necessary to identify the learning outcomes demanded by the training, which also correspond to the types of knowledge that are necessary for the implementation of both daily routine operations and non-specific activities. To achieve this purpose, and to align the elements together, the team developed Learning Outcomes, Information Literacy Domains (Skills from the Competency Tree), and Types of Knowledge Matrix. Two levels of achievement (basic and advanced) were defined for the different types of

Fig. 1. The interactive wheel for the IL competency tree defined by the NAVIGATE Project.

knowledge. By choosing an information literacy model to structure the game, we then created guiding documents to situate the game and the resulting learning mechanics for each setting.

2.3 Framing the games from a technological model

To assist in the development and implementation of the NAVIGATE games, the team developed a series of documents describing the game design process to be further used by librarians and teachers when planning game-based activities. A Handbook with scenarios for the information literacy games has been produced. In addition to the quantitative methods used in the evaluation of the students' achievements described in the Handbook document, a qualitative approach was also planned to measure learning outcomes achievement. Game mechanics (e.g. duration, points, rewards, role play, levels) have been linked to pedagogical intentions to help learners achieve designated learning outcomes.

2.4 Genres and short description of the games

The *The Navigator*[4] is a storytelling based mini-game (Fig. 2) whose main purpose is raising the awareness of first year HE humanities students regarding the

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[4] http://www.ce.unipr.it/navigator

risks related to the quality of information content and sources available to them. The story behind the game is an assisted investigation to dismiss the unproven claim by a foreign dictator maintaining Christopher Columbus was actually born in his country and not in Italy. The CRAAP (Currency, Relevance, Authority, Accuracy, Purpose) test model was embedded in the game to provide players with the capability of evaluating academic sources.

The game starts with the breaking news about the dictators tweet with his incredible claim, followed by a chat-based dialogue between the player and an AI-based robot assistant. Players are presented multiple documents from heterogeneous sources and guided to ponder and question them. The dialogue is simulating the social texting apps and providing information as chat threads where players are asked to answer some questions and either confirm or reject some explanations proposed by the robot. Through these interactions, players are involved in the application of the CRAAP criteria and can thus improve their basic information literacy skills.

The *Information Trap Manager*[5] game is a board adventure (Fig. 3) whose purpose attains middle level and advanced IL competences for undergraduate students approaching their degree. The game recreates a colorful and appealing learning experience in a cartoonized university campus in which students fine tune their IL preparation. Players have to roll the dice and keep moving around the campus board to explore the eight learning outcomes (as identified in the initial research phases) in buildings and places while facing a series of challenges related to Information Literacy.

Learning is attained in the board through seven distinct components. Students' dormitory and student's Cafe are allowing players to explore their progress and learning achievements, receiving insights and advice to improve their progress. Students' Club consist of a Tip and trap cards generator and at each visit it generates new two cards so players have to decide which one is tip with true information and which one is filled with false information related to information literacy. Tip cards also are useful and can be used as a help when answering the board questions. The Examination center which allows players to make the final exams in the game where also can repeat the exam to improve their learning and results through quantitative and qualitative feedback.

In terms of playing mode, *The Navigator* was structured and developed as a single player game in which the player has to collaborate with a virtual assistant, whereas *The Information Trap Manager* was designed to support multiplayer mode to offer several competition and collaboration opportunities and sharing experience between players. However, due to some limitations in time and resources, we decided to release it as a single player version to be followed later on by a multiplayer version. In terms of development technology, both NAVIGAME games are implemented to be platform-independent using UNITY 2D with WebGL, which is a JavaScript API for rendering high-performance interactive 3D and 2D graphics. This can provide transparent accessibility using web browsers, operability across multiple platforms and devices, and adaptive learn-
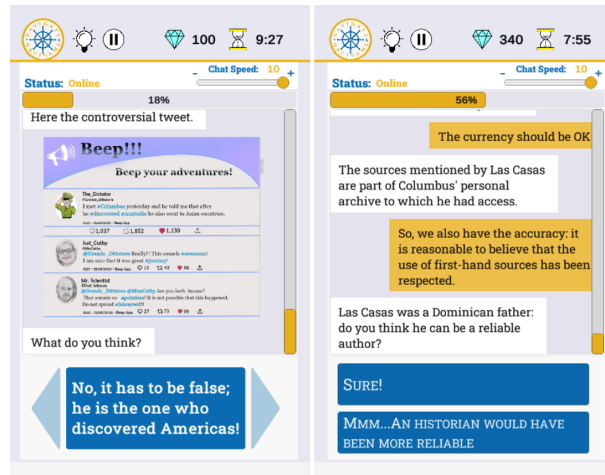
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[5] http://www.ce.unipr.it/itm

Fig. 2. *The Navigator*, a text-adventure game.

Fig. 3. *The Information Trap Manager*, a board-adventure game.

ing environment to promote learning everywhere using smartphones, tablets and desktops.

3 Learning Assessment

3.1 User testing and feedback

The two serious games have been tested in different events during 2020: in January in Gavle Workshop, in July in Parma during a Hackathon and a Workshop, in September during a Conference in Milan. The participants in the Workshops were teachers, librarians, and students (in total about 100 participants). The tests focused on collecting suggestions for improvement for game mechanics, including assessment.

Teachers, instructors, librarians and students have been actively involved in the testing and prototyping phases of the games and both instructors and students could report a widespread need for new ways and tools to increase engagement and competences in education. The two Serious Games have been extensively revised and retuned according to the feedback received during the sessions. In particular, as far as learning assessment is concerned, teachers' feedback has been highly positive, even from techers who reported their unfamiliarity with videogames.

3.2 Aligning game mechanics with learning assessment

One difficulty that the NAVIGATE project encountered was that of aligning game mechanics with learning assessment. An attempt has been made to solve this problem by using expected outcome rubrics. The NAVIGAME game mechanics is related to specific information literacy learning mechanics. Articles (*e.g.* [7]) outlining these connections typically relied on the transcription of declarative learning tasks in digital environments, often through the use of multiple choice, true / false, or other question and answer mechanisms. Multiple choice questions alone cannot support higher order learning outcomes. Therefore, continued research into Game-Based learning that promotes analysis, assessment and synthesis is important. Authors choose an approach to promote reflection and evaluation within their selected information literacy model, aligning specific game mechanics with learning mechanics.

The two NAVIGATE games have different aims and learning objectives, thus they have different learning assessment methodologies. To juggle humanities studies and information literacy outcomes of *The Navigator* we used the CRAAP (Currency Relevance Authority Accuracy Purpose) test model. The learning outcome to achieve is to remember the criteria of CRAAP evaluation. Also, as humanities students overestimate often themselves, the other outcome of *The Navigator* is to stimulate reflection and students self-assessment. We first created a stop for each step of the guided resources evaluation criteria process. Next, we selected predefined resources that correspond to these lines.

Table 1. The learning assessment in *The Navigator* game.

Learning Outcome	:D	:)	:|
	800-1000 points	600-800 points	< 600 points
Remember the importance of CRAAP (Currency, Relevance, Authority, Accuracy and Purpose) criteria	Mission accomplished! You are able to evaluate your sources!	Mission quite accomplished!! You can improve your skills to evaluate your sources!	Mission failed You are not able to evaluate your sources! Try again and do better!

Table 2. The learner self-assessment in *The Navigator* game.

How confident are you in the evaluation of sources?		
:D	:)	:|
Yes, very much;	Yes, but I need to learn more;	No, I am not capable

As the purpose of *The Navigator* is to stimulate motivation to know and learn more about IL, the learning assessment is based on the achieved points gained in the game for right answers (Table 1), while after game completion the player has to perform a self-assessment. The player is asked to critically reflect about the self confidence he/she has acquired in using the CRAAP criteria (Table 2). We restate that the *The Navigator* game was conceived as a IL introductory tool for freshmen of humanities degrees.

Regarding the *The Information Trap Manager*, we imagined players acquiring basic and advanced skills in identifying different types of information sources, creating effective database searches, applying information evaluation criteria, selecting information to answer a designated research question, sharing information professionally and ethically, and creating, managing and presenting their own content. With this general idea established, we have placed the learning mechanics within an in-game table (Fig. 4) illustrating the learning mechanics for the first two learning outcomes.

We then completed this process of applying the learning mechanisms for each phase of the Information Search cycle.

4 Discussion and further research: Game Learning Analytics

Both NAVIGATE games have been endowed with forms of learning assessment aligned only to some extent with our games mechanics, as the current assess-
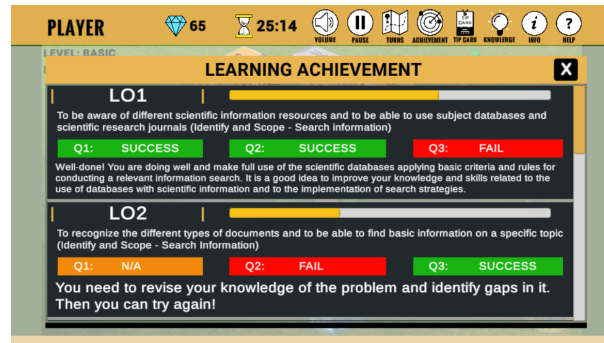
Fig. 4. The Learning Achievements Report in the Information Trap Manager Game.

ments are providing a general estimation for players related to their attainments and knowledge. For instance, the Learning Achievements report in the ITM game (see Fig. 4) is providing both qualitative and quantitative feedback related to the learning achievement for a specific learning outcome. However, these sorts of assessments and reports are providing only partial information with respect to the whole gameplay activities. The experience of the NAVIGATE Project has shown us that further research needs to be done on game assessment.

Generally, gameplay is related to the way of playing games based on certain rules as a series of interactions and activities. According to [8, 9], gameplay interactions can be tracked and analyzed in order to extract patterns and useful information for players and other stakeholders during the gameplay. In this regard, Freire et al. in [8] also have described five stakeholders in the logical architecture of their generic game learning analytics, students, instructors, educational supervisors, game developers and system administrators.

From an educational perspective, student players need to learn, view their learning progress and see how they perform during the gameplay as well as to see their levels and compare them to their peers. This would improve their learning experience and allow them to have more guidance and clearer expectations about their weaknesses and expected performance in any future formal assessments. On the other hand, observing players interactions and having deep analytics on the obtained data would allow instructors and educational supervisors to realize how players apply domain knowledge, in addition to the effectiveness of the learning material and pedagogy that applied in the game. In particular, understanding behavior of students and effectiveness of learning are crucial in the purpose of improving learning practices and making evidence-based decisions to enhance learning outcomes for students. Also, for game designers it is important to understand how effective the gameplay is and how learning is aligned with the game mechanics to gain a maximum of learning and entertainment.

Furthermore, to capture and evaluate players interactions during the gameplay, we would need a model capable of handling both learning interactions, to

evaluate players learning performance, and further gameplay interactions. The latter could be highly revealing regarding players' behaviour, play and completion time and measuring how much game mechanics are responsive to the player's needs. In this context, two common approaches have been followed in the literature. Several researches have tracked only the significant change in the knowledge away from other considerations by assessing players' knowledge before playing and after playing using the so-called pre-test and post-test assessments [10, 11]. Others have chosen instead to use some mixed methodologies to combine the pre-test and post-test with tracking and analyzing learning data and gameplay data to give a comprehensive understanding of players interactions [12–15].
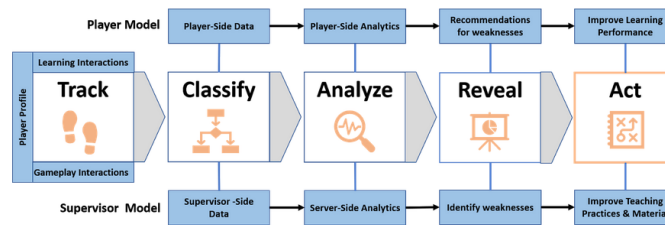

Fig. 5. The Navigame Learning Analytics Model.

Considering these research results and our previous work, we foresee the opportunity to expand the scope of NAVIGATE research introducing a NAVIGAME Learning Analytics (NGLA) model (Fig. 5). The main objective of the proposed NGLA is to design, develop and validate a game learning analytics model in order to provide:

– proactive prediction for the students learning performance in future formal assessments to enhance motivation and guidance;
– evidence-based decision for stakeholders to improve the educational practices;
– profile-based recommendations of learning practices and materials to provide personalized learning paths.

The proposed NGLA describes serious game learning analytics through five stages linked with the player model and supervisor model. The two models are giving more specifications to adjust the needs of each actor at each stage of the game learning analytics. while the five stages are starting from tracking the player profile data, learning data and other gameplay interactions followed by a data classifier to clean data and classify it according to each model. The third and fourth stages where the real processing and analysis are taken to reveal information and recommendations to the player and supervisor. Our intention here is to adapt and leverage upon the User Profiling and Recommendation System [16] to the needs and purposes of learning in HE. Finally, there is an Act stage

where actions need to take place from players to follow the recommendations in order to improve their weaknesses, and/or from supervisors to improve teaching material and practices.

Our research work will be based on relevant literature and on the lessons and experience gained in NAVIGATE. We will also try to correlate players performance and behaviours in the games with the outcomes they obtain in regular university exams. We plan to implement the NGLA model both for the two NAVIGAMEs and for a new serious game to learn the fundamentals of Computer Programming in courses of the first year of the Computer Engineering degree. The data capture component will be based on the Experience API (xAPI)[6].

Conclusions

Teachers and librarians need to overcome students' limited attention span and overestimation of their own digital skills, to highlight the risks of the information age and to help building information literacy competences. The Erasmus+ NAVIGATE Project has pursued active and Game-Based IL learning by proposing an interdisciplinary methodology focused on multiple key aspects. The main outcome was the development of two NAVIGAME serious games for IL with different purposes and characteristics.

However, multiple choice questions alone and the other assessment techniques used by NAVIGATE games cannot support the evidence of the achievements of higher order learning outcomes. Therefore, continued research into Game-Based learning that promotes analysis, assessment and synthesis is important. The testing and prototyping of the two Serious games have allowed us to obtain some valuable insights on how to improve the assessment of learning.

Besides carrying out final validation tests for the NAVIGAMEs with students, we are going to implement and validate the NAVIGAME Learning Analytics model with our serious games. Our research will have to tackle a number of issues and design choices, regarding what kind of game data we want to capture, the statistical or machine learning techniques to use in order to analyze captured data, as well as what aspects we want to focus on in the evaluation, i.e. players knowledge, learning performance, usability of the games, behaviors and attitudes.

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