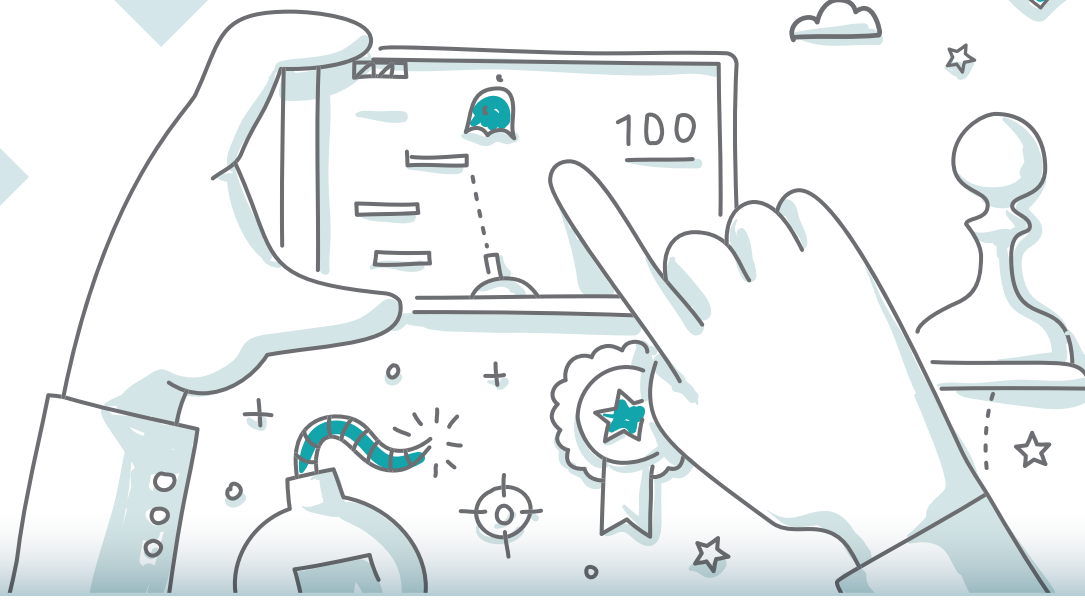
Triseum Game-Based Learning Validation Study

EVALUATION REPORT



European Schoolnet

triseum™

Julius-Maximilians-
UNIVERSITÄT
WÜRZBURG

Authors:
Jennifer Tiede and Silke Grafe
University of Würzburg

With contributions by
Anja Balanskat and Adina Nistor
European Schoolnet

Please cite this publication as:
Tiede, J. and Grafe, S. (2018). *Triseum Game-Based Learning Validation Study Evaluation Report - 2018*, European Schoolnet, Brussels

Publisher
European Schoolnet (EUN Partnership AISBL)
Rue de Trèves 61
1040 Brussels
Belgium
www.europeanschoolnet.org

Picture credits
Cover, rassco/Shutterstock.com, pp. 3-5 European Schoolnet, pp. 32-44-48-60-61-62 ARTé: Mecenas / Variant: Limits game by Triseum

Graphic design and DTP
Jessica Massini

Published
June 2018

EXECUTIVE SUMMARY

Project context and research questions

The game-based learning validation study, conducted by Triseum™ and European Schoolnet, was an international case study project which followed the purpose of testing and evaluating game-based learning with two educational games in European schools. The two games in the study were ***ARTé: Mecenas™***, an art history game about the Italian Renaissance, and ***Variant: Limits™***, a mathematical game about calculus, both published by Triseum, an educational game studio based in the US.

The project evaluation was carried out by the team of the chair of school pedagogy, University of Würzburg, in cooperation with European Schoolnet. The aim of this project was to research the impact of game-based learning using two Triseum games with respect to motivation and learning outcomes as well as the potential and limitations of their classroom implementation in different international contexts. The research questions were:

- **Does the game-based learning approach increase student motivation to learn and classroom engagement in the pilot project?**
- **How is game-based learning implemented within a K-12 environment in the pilot project?**
- **Do students gain content knowledge from playing *ARTé: Mecenas* and *Variant: Limits*, when these games are integrated into lesson plans?**

The project runtime was from July 2017 to June 2018. The test group was a convenience sample and consisted of 20 teachers who came from Norway, Poland, Greece, Italy, and Portugal. The teachers were trained to operate and implement the games and to design learning scenarios in online webinars and in two face-to-face meetings which were organized in Brussels.

Methodology

The triangular evaluation approach for this case study research included two questionnaires (pretest and posttest) and focus group discussions.

The pretest served to collect data on the composition and characteristics of the test group, e.g. with regards to teaching experience or perceived self-efficacy and beliefs. The posttest provided information on the game implementation and on the effects on students, including motivation, classroom engagement, and knowledge acquisition, as well as on future perspectives and suggestions for improvement. The focus groups explored in greater depth the impact on students and the ways of implementation.

Both the questionnaires and the focus group sessions were developed in accordance with related literature to ensure meaningful and valid results.

Summary of results

Motivation and classroom engagement

Overall, both the questionnaire data and the focus group discussions revealed a strong motivational potential of game-based learning with respect to ***ARTé: Mecenas*** and ***Variant: Limits***. The questionnaire data indicated slightly higher values for the motivational potential of ***Variant: Limits***, and the focus group analysis of this game was confirmative in this respect. In case of ***ARTé: Mecenas***, the results are not as one-dimensional because while teachers confirmed that ***ARTé: Mecenas*** had a positive influence on the motivation of most students, there were circumstances and conditions under which the game had a demotivating effect. The direction that the motivational or demotivational potential may take is dependent on a multitude of factors. Some of these may be influenced, e.g., the teaching scenarios and settings in which the game is integrated, and other factors cannot be influenced or only indirectly by the selection of classes, e.g., general student performance. Yet, the teachers' overall impression of the motivational potential of both games and game-based learning can be summarized as positive.

It is consistent with this positive perception of the motivational potential that the teachers also confirmed a mostly high classroom engagement with the students in the project classes, both in the surveys and in the focus group discussions and with a slightly more positive tendency for ***Variant: Limits*** expressed in the surveys. While again, this observation cannot be applied to each student – which can generally never be expected due to heterogeneous groups –, most students showed behavioral, emotional, cognitive and agentic engagement.

Ways of implementation

The analyses of ways of implementation showed that the teachers faced different preconditions, e.g., in terms of heterogeneous student groups or technical equipment of limited availability, and came up with creative and unique solutions to meet their specific situations and implement the games with their students. They encountered some problems and usually found ways to overcome these. The teachers also described their unique implementation scenarios, which show certain trends: e.g., most teachers preferred to have their students play both at home and at school or in flipped classroom settings, they all designed a variety of teaching and learning activities to accompany the game use, and they experimented with social settings and had their students play in all kinds of combinations, ranging from individual play to teams, groups or even with the whole class.

Knowledge acquisition

The overall impact on knowledge acquisition was perceived as positive with both games and the game-based learning approach, as surveys and focus groups revealed. Students learned things within the scope of learning goals that was predefined by Triseum, and also beyond. In this context, it was central for a number of teachers to point out that ***ARTé: Mecenas*** helped their students acquire a broader image of the Renaissance times and contextualize their knowledge of contents and relationships, which was mostly understood as more important than learning about single artists or artworks. Likewise, the teachers from the ***Variant: Limits*** test group explained that the contextualization of limits was a central advantage of the game.

All in all, both the analyses of the questionnaires and of the focus group discussions revealed that the game-based learning approach as implemented by the pilot teachers fostered motivation, classroom engagement and knowledge acquisition successfully, and this classification matches the evaluation of the teachers, who mostly rated the project as "rather successful" or "very successful" in the contexts of both surveys and focus groups.

Recommendations

Recommendation 1: Consider and further investigate cross-national differences

Concerning the **cross-national applicability** of ***ARTé: Mecenas*** and ***Variant: Limits***, the pilot project has revealed an overall applicability for Norway, Greece, Poland, Portugal, and Italy, in so far as the objectives of stimulating motivation, classroom engagement, and content knowledge are considered. Yet, there are differences in the perceptions of facets as for example the range of content of ***ARTé: Mecenas***, which has been described as less relevant for the curriculum in Norway, but as too restricted for the curriculum of Italy which

covers more than the game contents in the context of Renaissance. Also, in the context of different experiences between countries, teachers assessed the fact that both games are in English language differently, and some teachers had problems with the English language and would like to see **translated versions**. However, this is a controversial idea, because other teachers also considered the foreign language an advantage and developed interdisciplinary learning scenarios which combined e.g. arts and language or mathematics and language. It could be a solution to offer a limited number of translated versions for the countries which expressed their interest, as for example Portugal and Italy. It could also be viable to include country-specific dictionaries with important keywords, or to do without translations and provide teachers who want to work with the games with Content and Language integrated Learning (CLIL) oriented approaches and ideas to support their individual learning scenarios.

Against the background of such varying experiences of different countries, it might be advisable to seek further investigations or studies which involve more European countries and employ a variety of further methods to amend the research results.

Recommendation 2: Consider and enhance teachers' preparation and support

The evaluation results showed that a careful **technical and pedagogical preparation and ongoing support** for teachers who intend to implement *ARTé: Mecenas* and *Variant: Limits* is vital for the success of the game-based learning teaching unit. It is strongly recommendable to offer supportive measures such as e.g., videos, presentations, downloadable contents and live support. Another central idea in this context is establishing networks between teachers interested and taking advantage of their experiences and communicativeness. Teachers should be considered stakeholders in the promotion and support of *ARTé: Mecenas* and *Variant: Limits* and be supported in their game-related exchange, e.g. by forums, chats, Twitter chats and other forms of personal learning networks. This is true not only for the context of *ARTé: Mecenas* and *Variant: Limits*, but also for game-based learning in general. The teachers in the validation study took advantage of their preparation and support throughout the project via various activities offered and organized by Triseum and European Schoolnet, such as face to face meetings in the EUN future classroom lab and several webinars, and it is likely that according measures can complement and enhance game-based learning scenarios also in other contexts.

Recommendation 3: Review, amend and add didactic and pedagogical materials

The selection of **didactic and pedagogical materials** which are recommended to accompany the games will have a sound basis if they include and build on the pilot project evaluation results. E.g., the evaluation report revealed the strength of a teaching approach that combines playing at home and at school lessons, as in a flipped classroom approach, because it has proven successful and efficient to accompany the students when playing actively, while giving them room to play freely and minimizing the classroom time needed, which is a requirement many teachers expressed. Also, the pilot project showed that learners' groups are heterogenous and that their characteristics have to be considered carefully to foster motivation, classroom engagement and content knowledge acquisition effectively, and to ensure a successful game implementation. Hence, future game-based learning teachers should be provided with respective scenarios, materials and stimuli to build on these experiences and enrichen them with own approaches.

Recommendation 4: Strengthen and further research game-based learning

Overall, the validation study revealed a strong potential of game-based learning as an approach to teaching and learning in terms of students' motivation, classroom engagement, and knowledge acquisition. The results suggest that game-based learning has proven successful, which leads to the conclusion that this approach should be proceeded with and strengthened in further research and practice, especially in view of a limited transferability due to methodological reasons and the exemplary selection of two games. For the research perspective, this might include e.g. research on further games and more effects beyond these that were focused in the validation study, using various methodologies and including diverse target groups. In terms of practical applications, the results offer a confirmation for developing, using and evaluating more game-based learning approaches in educational settings.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

Triseum™, an educational game studio based in the US, partnered with European Schoolnet to conduct a game-based learning validation study with two learning games *ARTé: Mecenas™* and *Variant: Limits™* in schools in Greece, Poland, Italy, Norway, and Portugal.

The scientific evaluation for this pilot was carried out by the team of the chair of school pedagogy, University of Würzburg, in cooperation with European Schoolnet.

The aim of this project is to research the impact of game-based learning with two Triseum games regarding motivation and learning outcomes as well as the potential and limitations of their classroom implementation in different international contexts. The research questions are:

- **Does the game-based learning approach increase student motivation to learn and classroom engagement in the pilot project?**
- **How is game-based learning implemented within a K-12 environment in the pilot project?**
- **Do students gain content knowledge from playing *ARTé: Mecenas* and *Variant: Limits*, when these games are integrated into lesson plans?**

The project runtime is from July 2017 to June 2018; the teacher involvement in the project started in September 2017. The test group is a convenience sample and consisted of 20 teachers from five European countries. The triangular evaluation approach includes two questionnaires (pretest and posttest) and focus group discussions.

The present document represents the final evaluation report which has the purpose of publishing all validation study outcomes. It includes an introduction to the evaluation methodology (chapter 2), pretest and posttest results (chapter 3), focus group analyses (chapters 4 and 5), a chapter on conclusions (chapter 6) and recommendations (chapter 7). Furthermore, the questionnaires and materials used for evaluation purposes as well as the learning scenarios developed by the teachers in the course of the project are included in the appendix.

2. METHODOLOGY

The research methodology for the evaluation of the European Schoolnet and Triseum™ game-based learning validation study was triangular and combined a pretest and a posttest questionnaire with focus group discussions. The questionnaires served to collect teacher information on a number of aspects.

The pretest focused on the aspects of composition and characteristics of the teacher group, pilot classes, teachers' experience with digital games, teachers' perceived self-efficacy and beliefs, and teachers' expectations with respect to game-based learning. The posttest included the facets of teachers' perceived self-efficacy and beliefs, pilot classes, game implementation, impact on student motivation, impact on student classroom engagement, impact on student knowledge acquisition, future perspectives, expectations, and overall rating with respect to game-based learning and the two Triseum games.

The focus groups collected additional qualitative insights on these topics by deeper exploring the game implementation, impact on student motivation, impact on student classroom engagement, impact on student knowledge acquisition, and potential for improvement with respect to the game-based learning approach.

2.1 Understanding of motivation and classroom engagement

Motivation

A well-established model of motivation is the ARCS model based on Keller (1987). It was designed to "find more effective ways of understanding the major influences on the motivation to learn, and for systematic ways of identifying and solving problems with learning motivation" (p. 1). Based on psychological research, the ARCS model defines four major conditions which have to be met for people to become and remain motivated. These four main fields are Attention, Relevance, Confidence, and Satisfaction.

For analyzing the motivational potential that the teachers in the pilot study attributed to the Triseum games, the ARCS model was taken as a basis, with operationalizations of the four main areas as suggested by Keller's (1987) strategies and by the game-specific IMMS by Huang et al. (2010).

Classroom Engagement

Classroom engagement is understood as the objective, publicly observable manifestation of the students' underlying motivational status (Lee & Reeve, 2012, p. 730). For the following analysis, the definition and operationalizations were applied as mentioned by Lee and Reeve (2012). The authors describe classroom engagement by four aspects:

1. **Behavioral engagement**, defined as the "extent of a student's on-task attention, effort, intensity and persistence in the face of difficulties" (Lee & Reeve, 2012, p. 733; Skinner, Kindermann, & Furrer, 2009),
2. **Emotional engagement**, defined as the "extent of a student's positive emotions during learning activity, such as interest and enjoyment, and absence of negative emotions, such as boredom and sadness" (Lee & Reeve, 2012, p. 733; Skinner, Kindermann, & Furrer, 2009),
3. **Cognitive engagement**, defined as the "extent of a student's cognitive and metacognitive strategies that involve meaningful (i.e. elaborative) processing attempts to connect or integrate new information with existing knowledge in an effort to form a richer, more coherent mental representation (Lee & Reeve, 2012, p. 734; Wolters, 2004; Elliot, McGregor, & Gable, 1999), and
4. **Agentic engagement**, defined as the "extent of a student's constructive contribution into the flow of the instruction she or he receives" (Lee & Reeve, 2012, p. 734; Reeve & Tseng, 2011).

2.2 Pretest and posttest methodology

The pretest questionnaire (cf. appendix 10.1) was distributed to the teachers after a first introductory webinar and before they received any detailed information on game-based learning and the Triseum games in order to assure uninfluenced baseline data. It was published as an online survey which took the teachers about 30 minutes to complete. It mainly consisted of closed questions, which were amended by a few open questions. The posttest questionnaire (cf. appendix 10.1) was distributed to the teachers towards the end of the project, after the second face-to-face meeting in Brussels and at a time when most teachers had finished the implementation phase. It was also published as an online survey and required about 30 minutes to complete. The completion rate of both surveys was 100 %.

2.3 Focus Groups methodology

As suggested by Krueger and Casey (2015), the focus group was structured by a questioning route which was developed in seven steps: 1) Brainstorming, 2) Sequencing the questions, 3) Phrasing the questions, 4) Estimating time for each question, 5) Getting feedback from others, 6) Revising the questions, and 7) Testing the questions (performed as an intense and iterated reflection and revision within the project team) (pp. 60-71). The questioning route included the following elements and sections: 1) Introduction, 2) Opening question, 3) Introductory question, 4) Three key questions on the implementation and one key question on effects on students, 5) One optional question on future perspectives, 6) Two ending questions, and 7) A summary and ending.

The focus groups were integrated into the second face-to-face workshop with teachers, organized in Brussels in February 2018 (6 months following the teachers' engagement in the pilot). 18 out of 20 teachers participated in the focus group sessions. These teachers were split into four groups of four to five teachers each, with two groups per game. The duration of the focus groups was set at two hours. These structures are in accordance with related literature (cf. Krueger & Casey, 2015; Litosseliti, 2003).

The focus group sessions were audio recorded, transcribed and analyzed by means of a qualitative content analysis as proposed by Mayring (2015). The approach was of deductive nature, which means that an elaborate category system was developed first, based on literature and for the purpose of specifying the aspects of the research questions. In a second step, the material was searched for evidence of these categories and indicators and coded by using the coding software MAXQDA. The codings were then structured and summarized to give a comprehensive overview of the results.

2.4 Description of sample

2.4.1 Number of teachers

N=20 Teachers (12 female, 8 male).

2.4.2 Teacher age

Teachers are aged 32-56 ($\bar{x}$=45, SD=7.5)[1]

1 $\bar{x}$ indicates the mean value, SD refers to the standard deviation.

2.4.3 Geographical coverage

The geographical coverage is balanced. There are n=4 teachers from each of the following countries: Portugal, Greece, Italy, Poland, and Norway.

2.4.4 Teaching experience

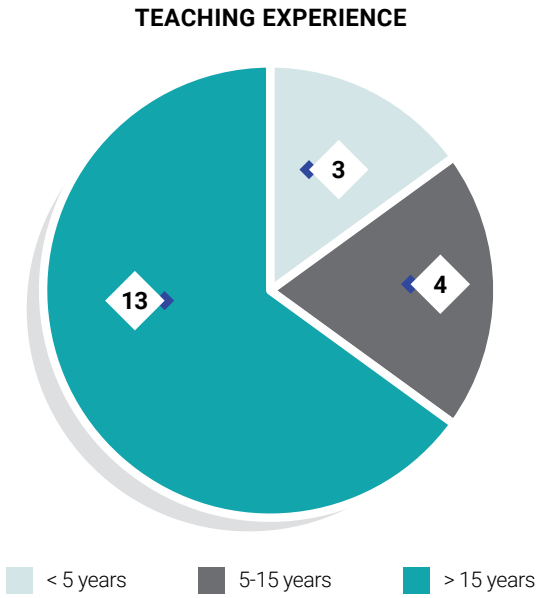


Chart 1: Teaching Experience

The group of participants is quite experienced. A majority of teachers has more than 15 years of teaching experience (cf. chart 1).

2.4.5 Education level and subjects the teachers usually teach

All of the teachers are secondary school (high school equivalent in the US) teachers. They cover a variety of subjects which they teach in their regular classes. The most frequently listed subjects are mathematics, history, local/native language and culture, art history, and religion/ethics (cf. chart 2).

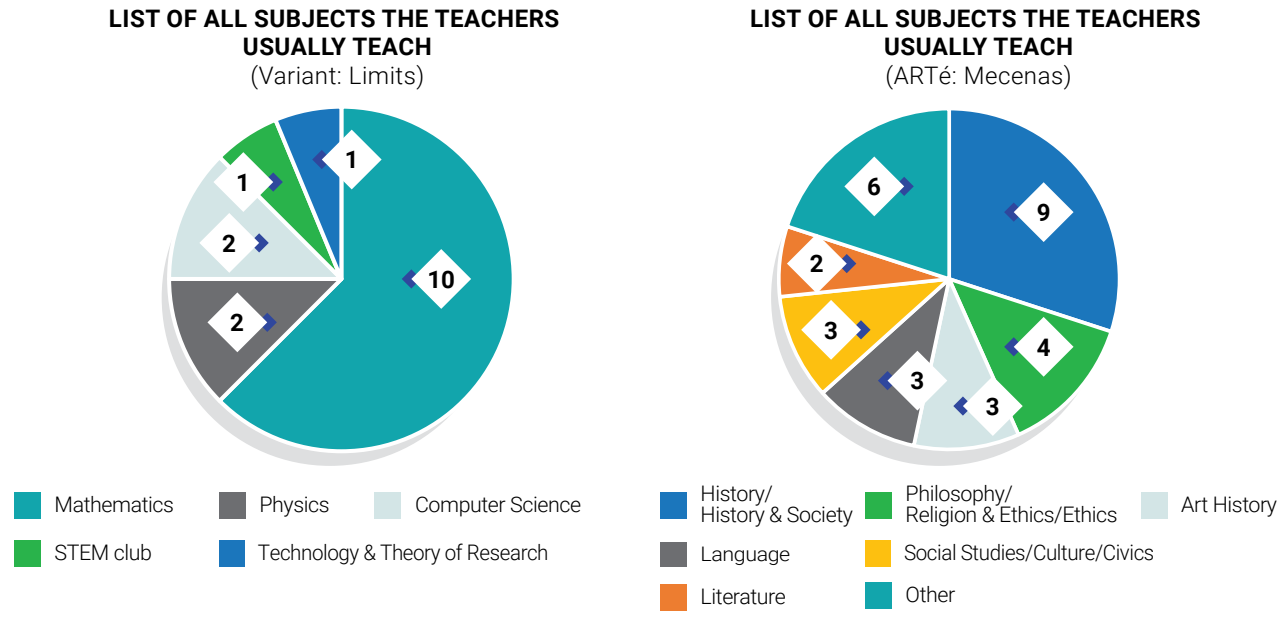


Chart 2: All teacher subjects

2.4.6 Teachers and the Triseum games

Half of the teachers worked with ***ARTé: Mecenas™*** (n=10) and the other half implemented ***Variant: Limits™*** (n=10). There were two teachers per country per game.

2.4.7 Ways of invitation

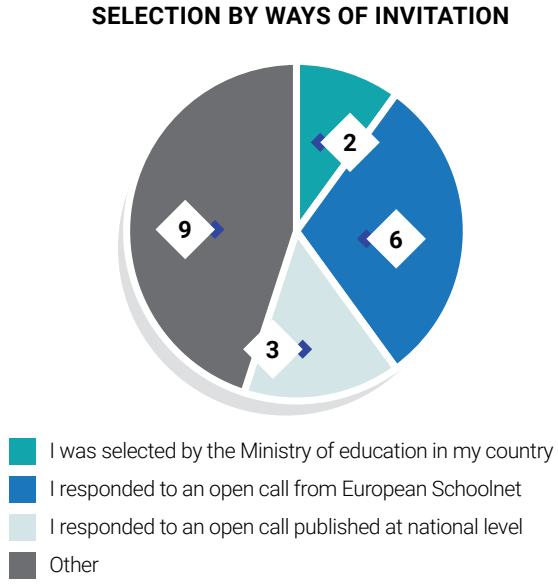


Chart 3: Ways of invitation

Teachers were invited to join the pilot project in various ways. 9 out of 20 teachers responded to an open call actively while the other 11 teachers were asked to participate either by their Ministry of Education or by other institutions or persons.

Answers from teachers who selected "other" included "I was asked by my headmaster/school" (2) and invitations by regional/national ICT centres (2), universities (2), EUN STEM Ambassadors (1), EUN (1), or specific persons (1) (cf. chart 3).

3. PRETEST AND POSTTEST RESULTS

3.1 Teachers' experience with digital games before the project

3.1.1 Gaming for entertainment

Most teachers are not frequent gamers. N=6 teachers play digital games for entertainment once per week or more often, n=9 teachers play once every few months or 1-2 times per year and 5 teachers indicate to never play digital games. With regards to the teacher groups using either ***Variant: Limits™*** or ***ARTé: Mecenas™***, the gaming habits of both groups are comparable (Cf. chart 4).

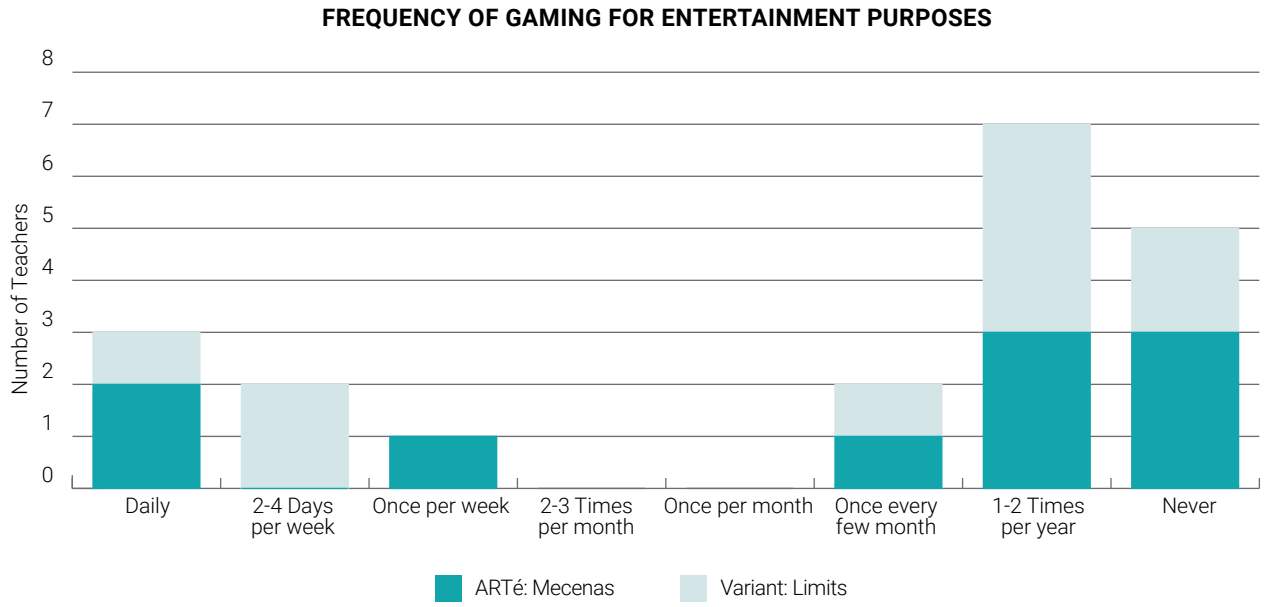


Chart 4: Gaming for entertainment

3.1.2 Experience with games for instructional purposes

The whole group of pilot teachers is rather inexperienced with using digital games in class. A majority of n=12 out of 20 teachers never uses games for instructional purposes. No teacher indicated to use games on a weekly or even daily basis (cf. chart 5).

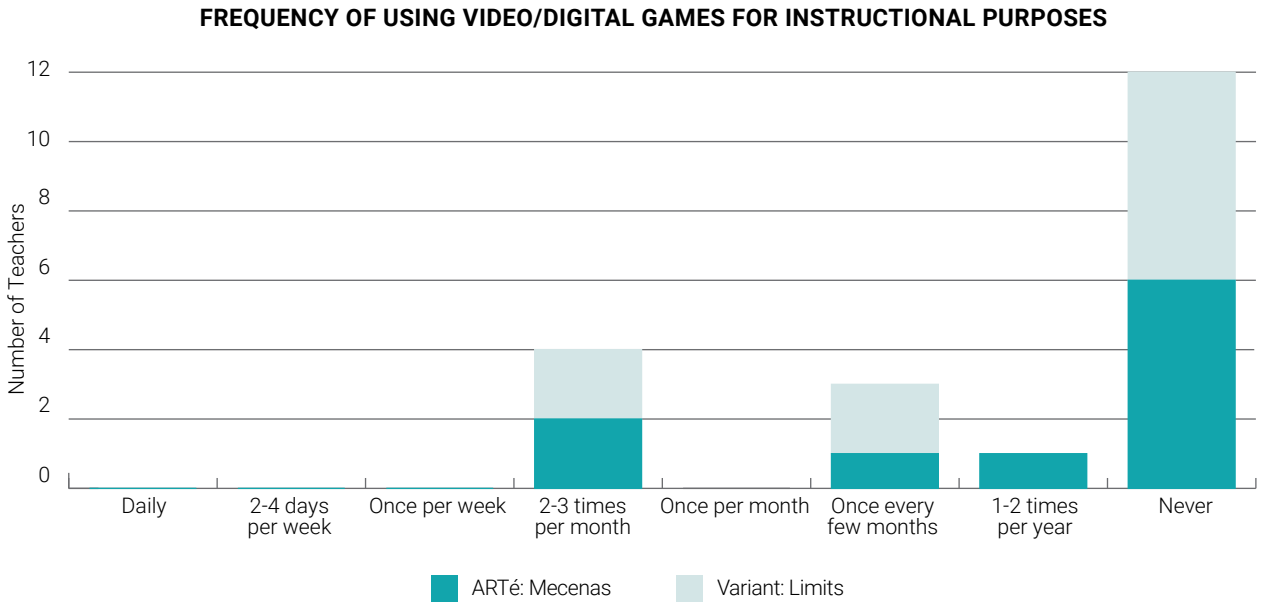


Chart 5: Games for instructional purposes

3.1.3 Types of digital games in class

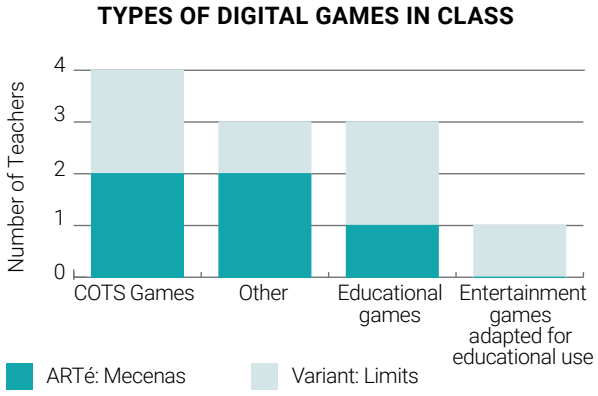


Chart 6: Types of games in class

A question about the digital games that students usually play in class was only answered by teachers who indicated to use digital games in class at all. Most of these teachers used Commercial-off-the-shelf-Games (4), two teachers use educational games and one teacher uses entertainment games adapted for education use. Three Teachers specified other types of games: "Escola Virtual", "Quizz", "Kahoot" and "Quizlet" (cf. chart 6).

3.1.4 Digital Games used in class

A question about concrete games used in class was only answered by teachers who indicated to use digital games in class at all. The following games were listed: Kahoot (3), Quizlet, Quizizz, Euclid the game, MathCaching, Mangahigh, This War of Mine, Just Dance 2017, Valiant Hearts, Kerbal, Space Program, Plague Inc, DragonBox, Hearthstone, The Walking Dead, The Witcher 3, Skyrim.

3.1.5 Primary reasons for using digital games in class

A question about primary reasons for using digital games in class was only answered by teachers who indicated to use digital games in class at all. All of the 8 teachers selected "triggering and supporting learning processes", which is the most frequent reason for using digital games in class. Within this group, a majority of 5 teachers indicated to use games for giving their students a break activity, and half of the teachers (4) selected "practicing material already learned" and "providing a tool for communication and collaboration". There was one additional reason mentioned under "other": "To increase motivation" (cf. chart 7).

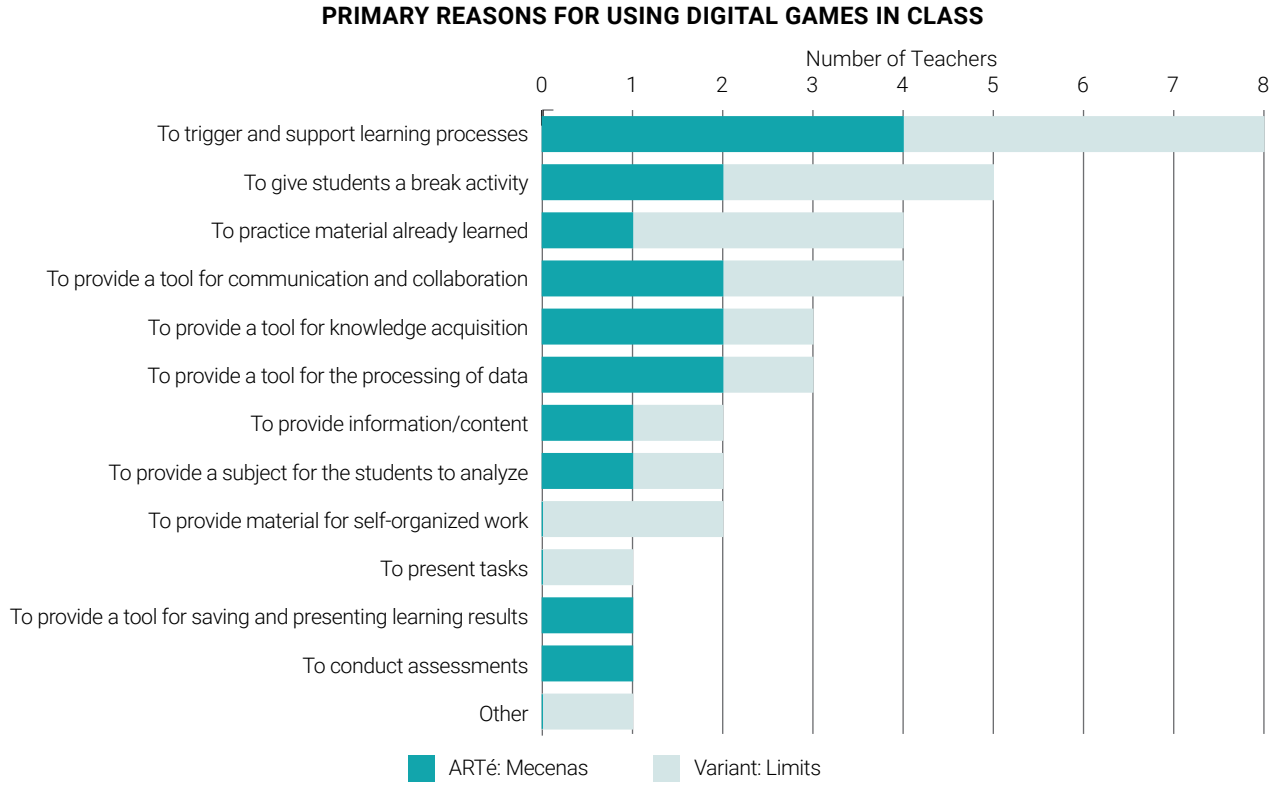


Chart 7: Primary reasons for using digital games in class

3.1.6 Barriers for using digital games in class

From a given list of potential barriers for using digital games in class, the greatest barriers teachers chose were "insufficient time" (13), "Hard to find games that fit curriculum" (13), and "not sure how to integrate games" (11). The following factors were chosen very rarely and do not seem to be a barrier to most teachers: "Low quality in graphics or audio effects in educational games" (1) or "Lack of parental support" (0). One teacher specified further barriers: "Problems with the hardware and the internet connection" (cf. chart 8).

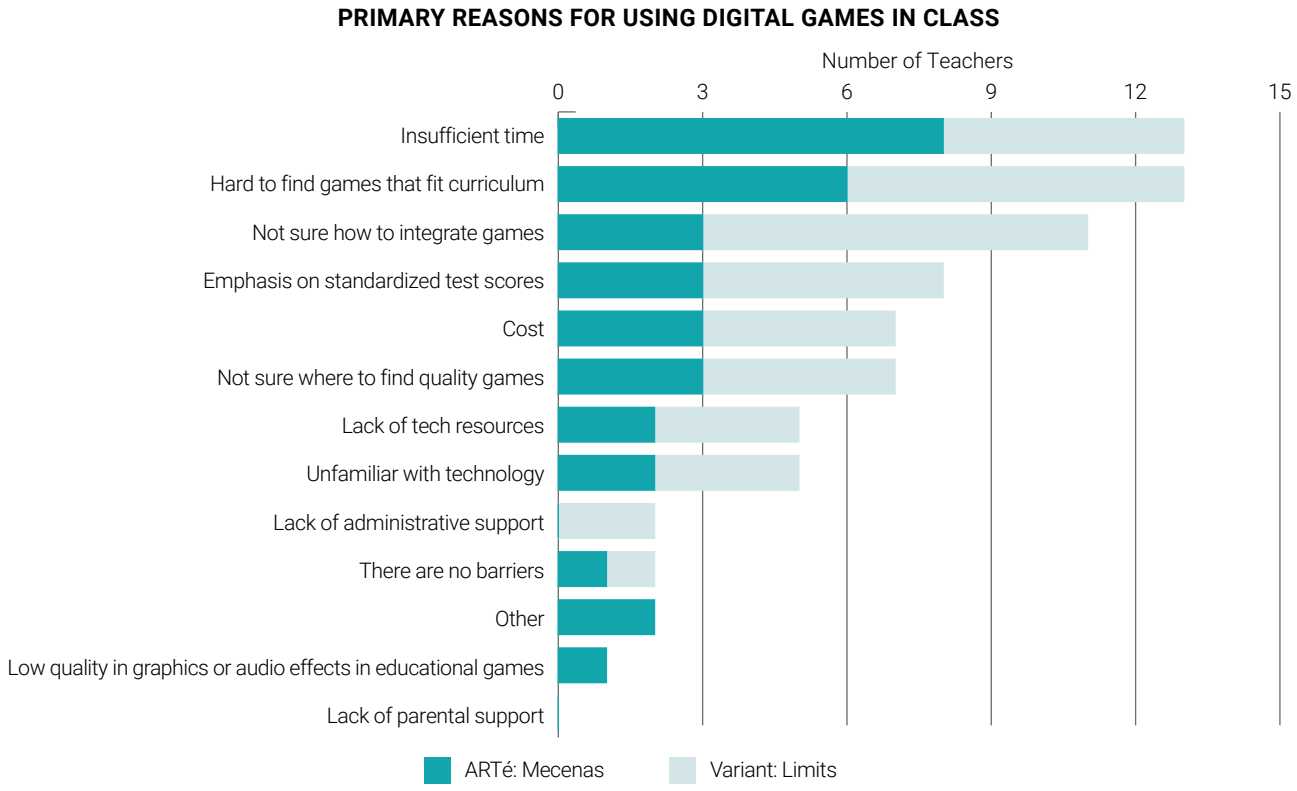


Chart 8: Barriers for using digital games in class

3.2 Teachers' perceived self-efficacy and beliefs (before and after the project)

3.2.1 Comfortability with the idea of using digital games as teaching tools

The teachers indicate prevailing comfortability with the idea of using digital games as teaching tools. 18 out of 20 teachers agree or even strongly agree with the comfortability statement in the pretest (cf. chart 9), and 19 out of 20 teachers agree or strongly agree after the project (cf. chart 10).

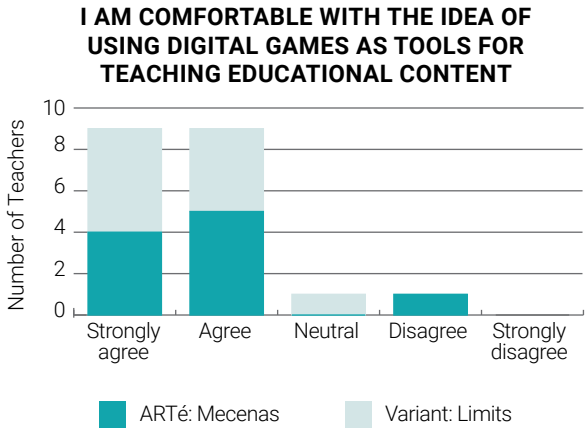


Chart 9: Comfortability with using digital games as teaching tools (pretest data)

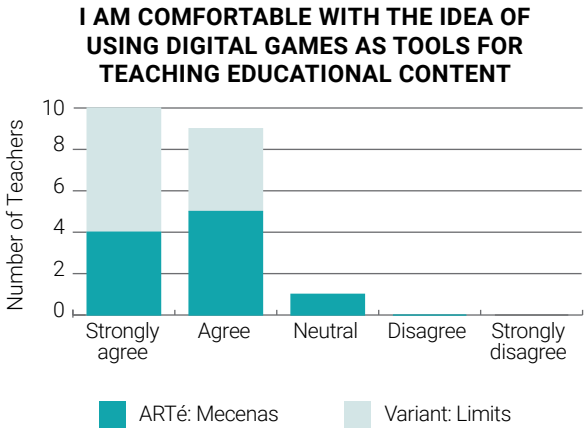


Chart 10: Comfortability with using digital games as teaching tools (posttest data)

3.2.2 Perceived capability of using digital games as teaching tools

The teachers show prevailing trust in their capability to use digital games to deliver educational content. There is no teacher who disagrees or strongly disagrees with the capability statement even before the project (cf. chart 11), and the posttest data show that the teachers' perceived capability slightly increased over the project (cf. chart 12).

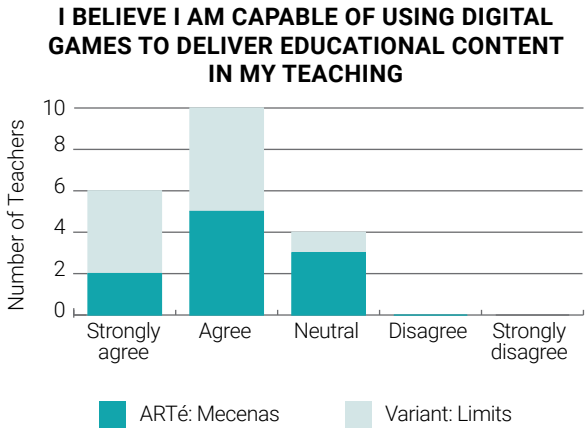


Chart 11: Self-perceived capability of using digital games as teaching tools (pretest data)

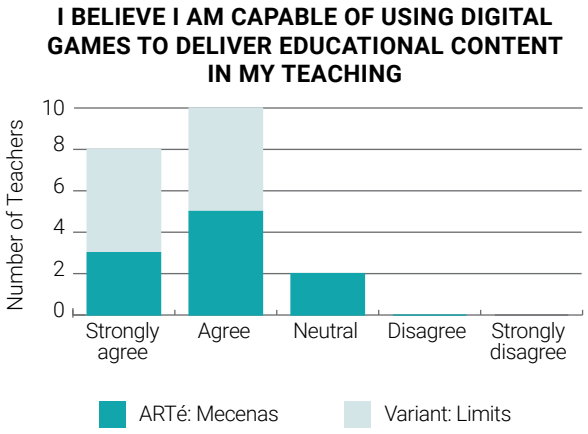


Chart 12: Self-perceived capability of using digital games as teaching tools (posttest data)

3.2.3 Reasons why digital tools can be useful tools for teaching

Teachers indicated their agreement with a number of statements on the usefulness of digital tools for teaching on a five-point scale (Strongly agree, agree, neutral, disagree, strongly disagree). Chart 13 displays the arithmetic mean of each statement as posted in the pretest and in the posttest in comparison, using the following values for each agreement statement: strongly agree = 5 points, agree = 4 points, neutral = 3 points, disagree = 2 points, and strongly disagree = 1 point.

The largest increases in the average means of teachers' beliefs between the pretest and the posttest have been found with regards to the following statements: "I myself played games and I learned through gaming", "Digital games bring me into a better position among teachers who are interested in using digital technologies for teaching", and "Nowadays students are more attuned to learning with digital media or new technologies". The average means of the following two statements slightly decreased over the course of the project: "They promote personalized learning" and "They increase student motivation to learn the content".

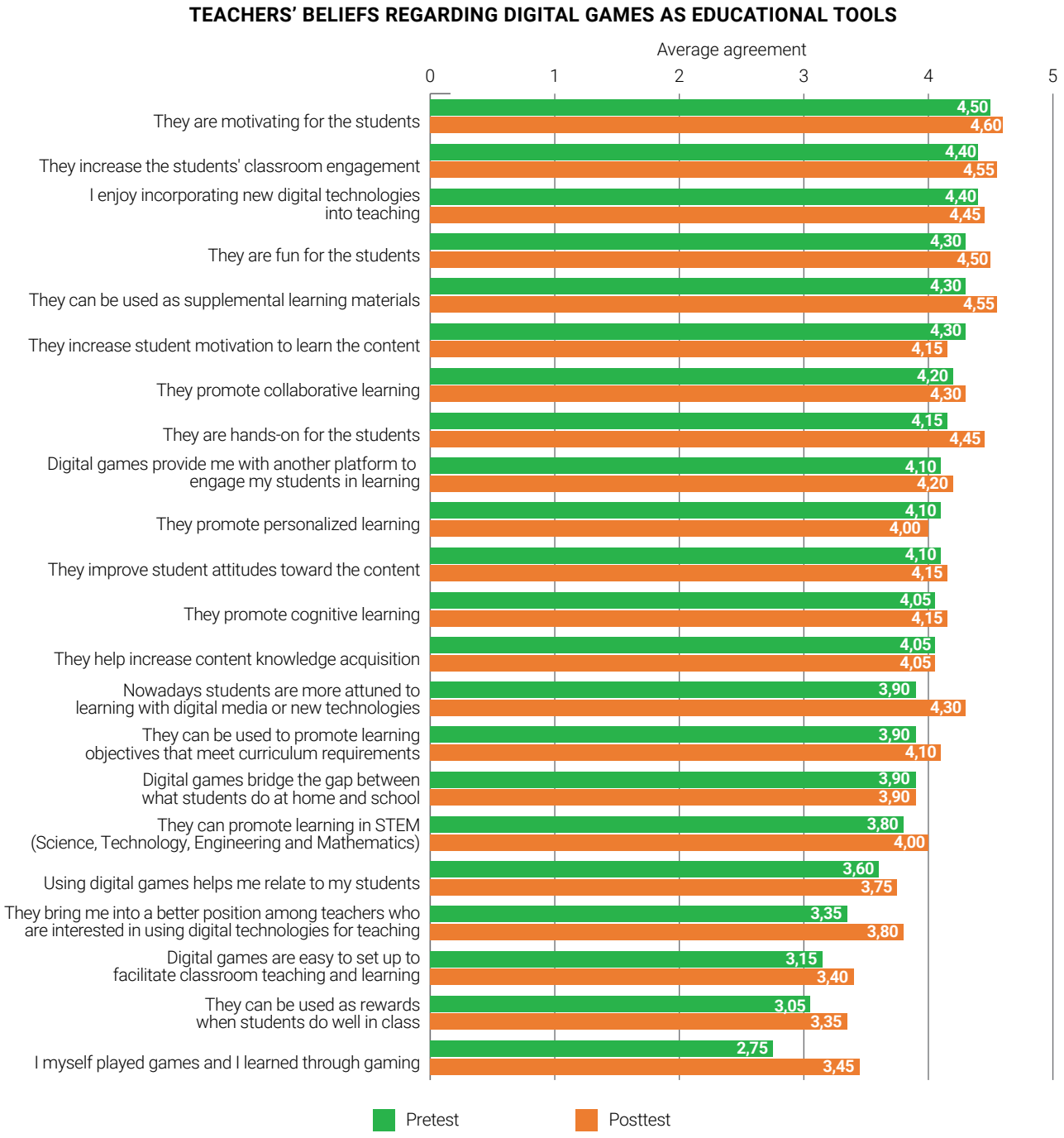


Chart 13: Teachers' beliefs regarding digital games as educational tools (pretest and posttest data)

3.3 Project Classes

3.3.1 Number of project classes per teacher

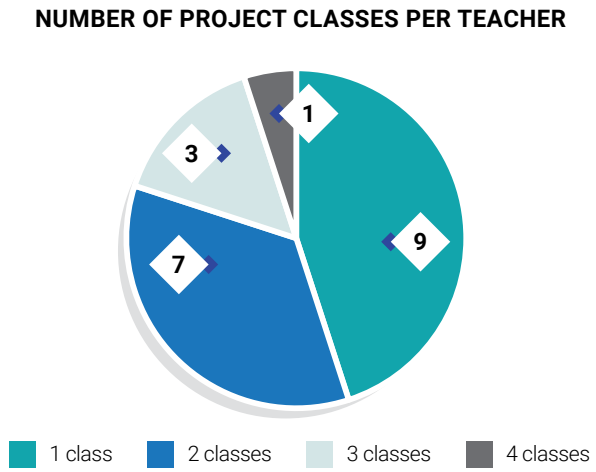


Chart 14: Number of project classes

Most teachers worked with one or two classes, but there were also teachers working with three or even with four classes in the project (cf. chart 14).

3.3.2 Total Numbers of Classes and students

The teachers further specified the number of classes and students as indicated in table 1.

Table 1: Total numbers of classes and students

	Total	ARTé: Mecenas	Variant: Limits
Number of classes	**36**	19	17
Student age	**16-30**	16-18	17-30
Number of students	**857**	472	385
Average number of students per class (SD)	**23.8 (4.7)**	24.8 (3.9)	22.6 (5.3)

3.3.3 Classes characteristics

The teachers were asked to briefly characterize their learners by an open answer. Table 2 summarizes the teachers' descriptions of their classes, grouped according to inductively derived categories.

For the interpretation of these descriptors, it should be kept in mind that this question was intentionally formulated open. The teachers described their classes with respect to the aspects they considered as predominant. The descriptors are not comprehensive nor selective, meaning that a class which was described as having a "high level of skills" could fall into the category of "motivated/interested and high level of skills", but also into the category of "talented but motivational issues". Against the background of these limitations, the table reveals that a high number of classes in the project have been described with positive descriptors like "motivated", "interested" or "with high level of skills". Only few classes have been labeled as overall problematic.

Table 2: Classes characteristics

	No. of classes: total	No. of classes: ARTé: Mecenas	No. of classes: Variant: Limits
Motivated/interested and high level of skills	**11**	3	8
Motivated and average level of skills	**1**	1	
High level of skills	**3**	1	2
Motivated/interested/active/creative	**4**	3	1
Average	**7**	5	2
Mixed: some students interested and/or with high skills, some students with difficulties	**5**	2	3
Interested but not very hardworking	**1**	1	
Talented but motivational issues	**1**	1	
Motivational or interest issues/uncooperative	**3**	2	1

3.3.4 Subjects

The teachers mentioned a variety of subjects where they integrated *ARTé: Mecenas*. For *Variant: Limits*, most teachers mentioned mathematics or a mathematics-related course, sometimes in combination with specific contents or subject areas, as for example in "Maths: Variant Limits, Continuity" (cf. chart 15).

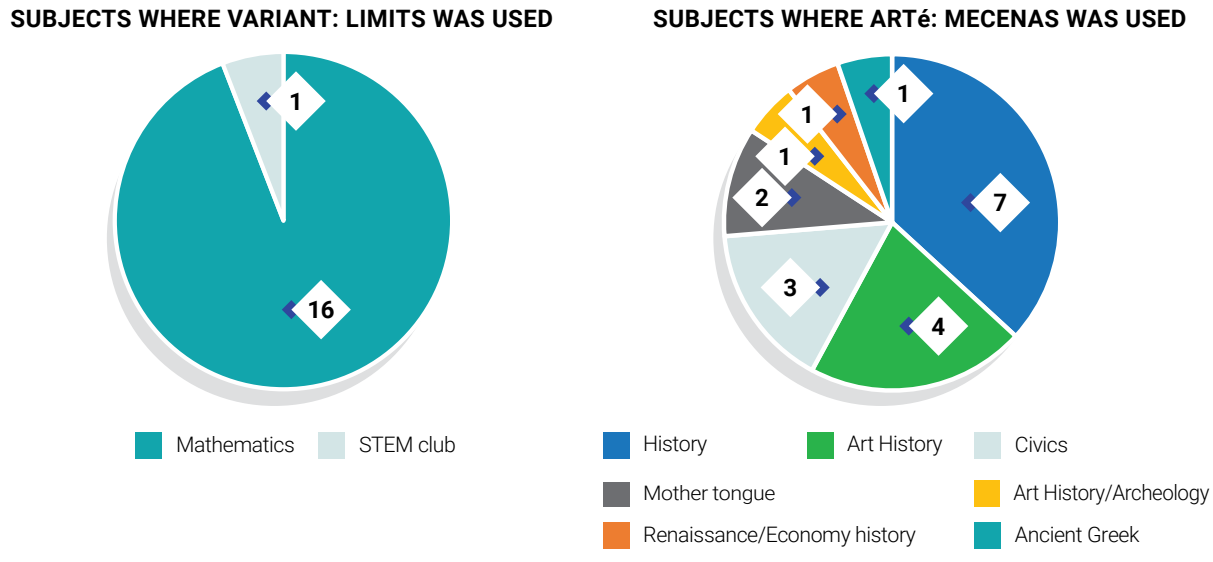


Chart 15: Variant: Limits and ARTé: Mecenas subjects

3.4 Ways of Implementation

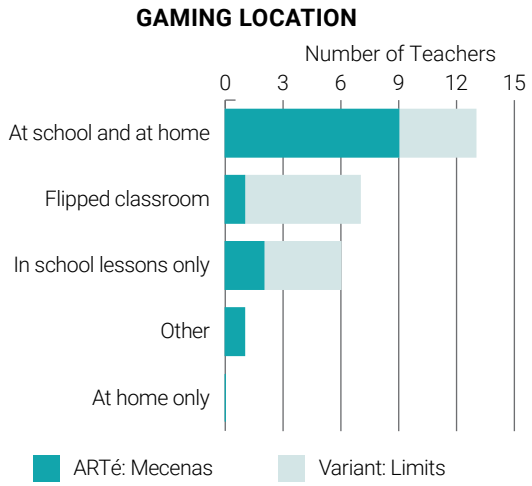


Chart 16: Gaming location

3.4.1 Gaming location

Most teachers combined using the game at school and at home (13). Several teachers especially from the ***Variant: Limits*** test group also integrated the game into a flipped classroom-approach (7), which means that the students mainly played at home while school lessons were used for group discussions, troubleshooting, further tasks etc. The one different scenario which was mentioned as "other" was "at LAB/library". Remarkably, there was no class which played at home only (cf. chart 16).

3.4.2 Main purpose of game use

Most teachers used the game to trigger and support learning processes (17), to practice material already learned (15), and to provide a tool for knowledge acquisition (14). In the pretest, the teachers indicated which purposes they generally see for game-based learning (cf. chapter 3.1.5 / chart 7). For a comparison of hypothetical and actual game uses, it is particularly noteworthy that a majority of teachers in the pretest (62.50 %) considered games an appropriate tool for giving their students a break activity, but only 20 % of all teachers indicated having realized this in the posttest (cf. chart 17).

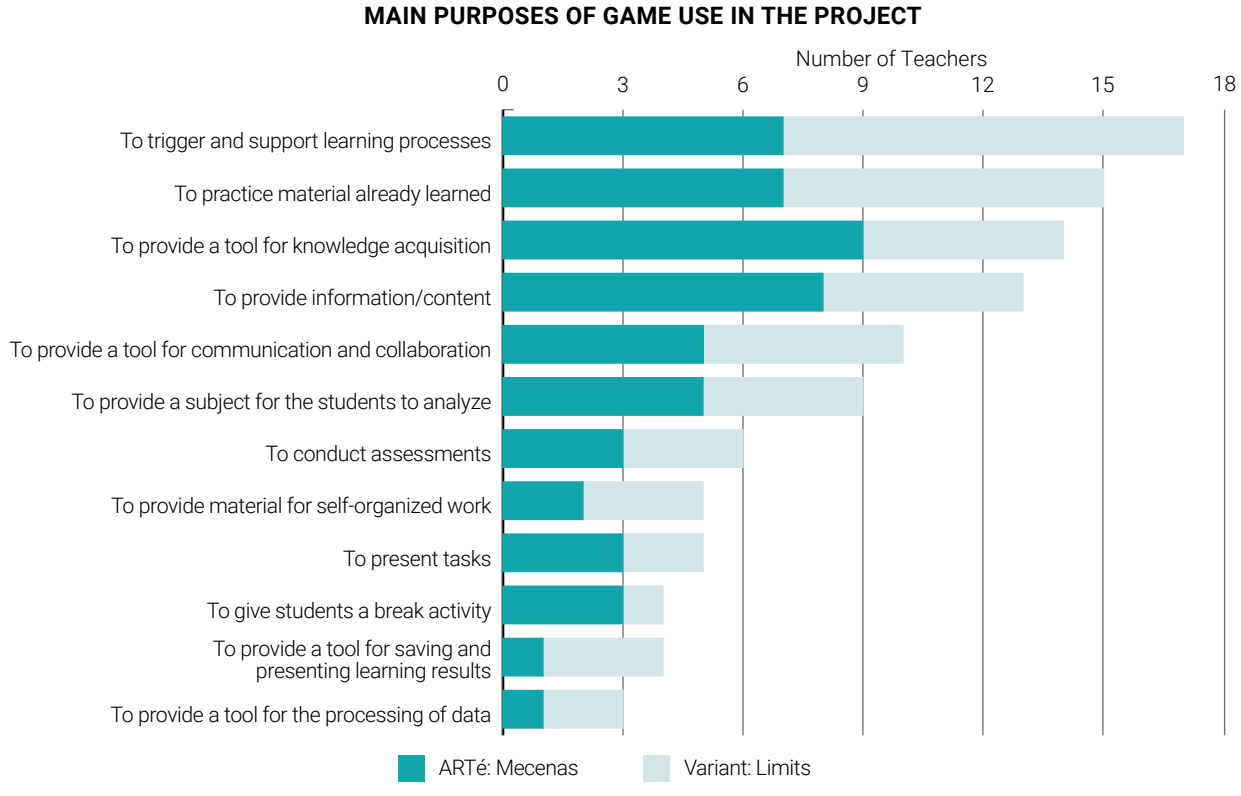


Chart 17: Purposes of game use in the project (posttest data)

3.4.3 Game introduction

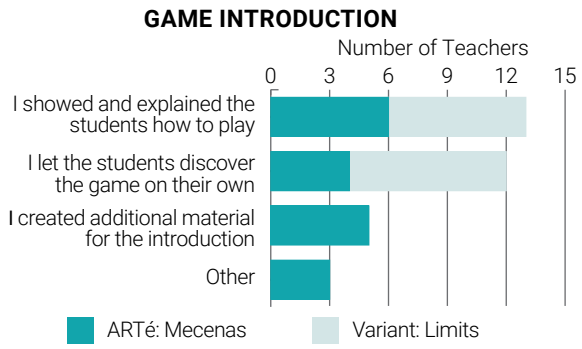


Chart 18: Game introduction

The teachers mostly showed and explained their students how to play (13) or let them discover the game on their own (12). Out of the three additional comments under "other", two related to modelling, i.e., some students took on the expert role and explained the others how to play, and one comment explained that the respective teacher "explained some info but let the students discover the rest" (cf. chart 18).

3.4.4 Social settings

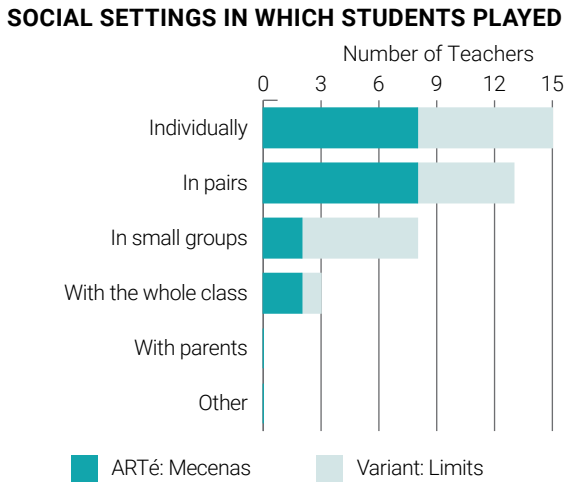


Chart 19: Social settings

The approaches of social settings that the teachers described were quite diverse. Individual (15), pair (13) and group scenarios (11) were all used (cf. chart 19).

3.4.5 Teaching and learning activities

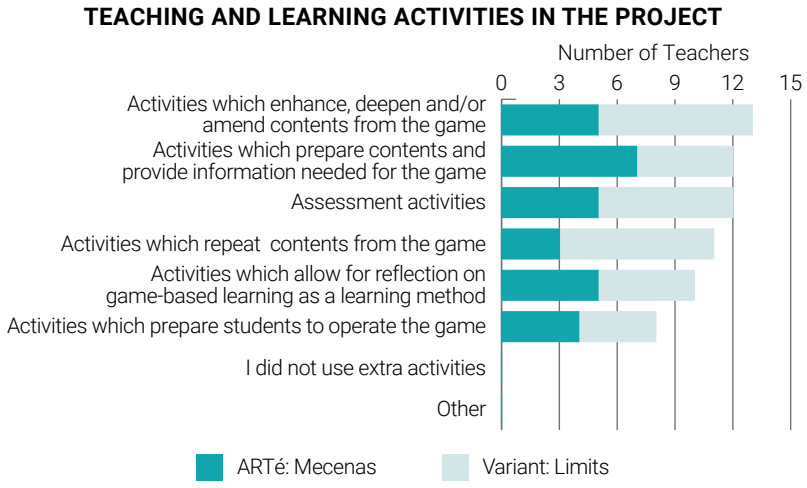


Chart 20: Teaching and Learning Activities

The teachers confirmed using all teaching and learning activities that were suggested in the posttest questionnaire item. Nobody used the games without any additional activities (cf. chart 20).

3.4.6 Barriers, problems and difficulties

The teachers listed a number of barriers, problems and difficulties that occurred in the course of the project. The problems that occurred most often were related to "insufficient time" (11), "technical problems with the game" (9) and "language" (7). Comparing these results to the pretest data where the teachers assessed respective problems in general, it is remarkable that 11 out of 20 teachers indicated generally being "not sure how to integrate games" in the pretest (cf. chapter 3.1.6 / chart 8), but only 3 teachers actually shared this problem in the pilot project (cf. chart 21).

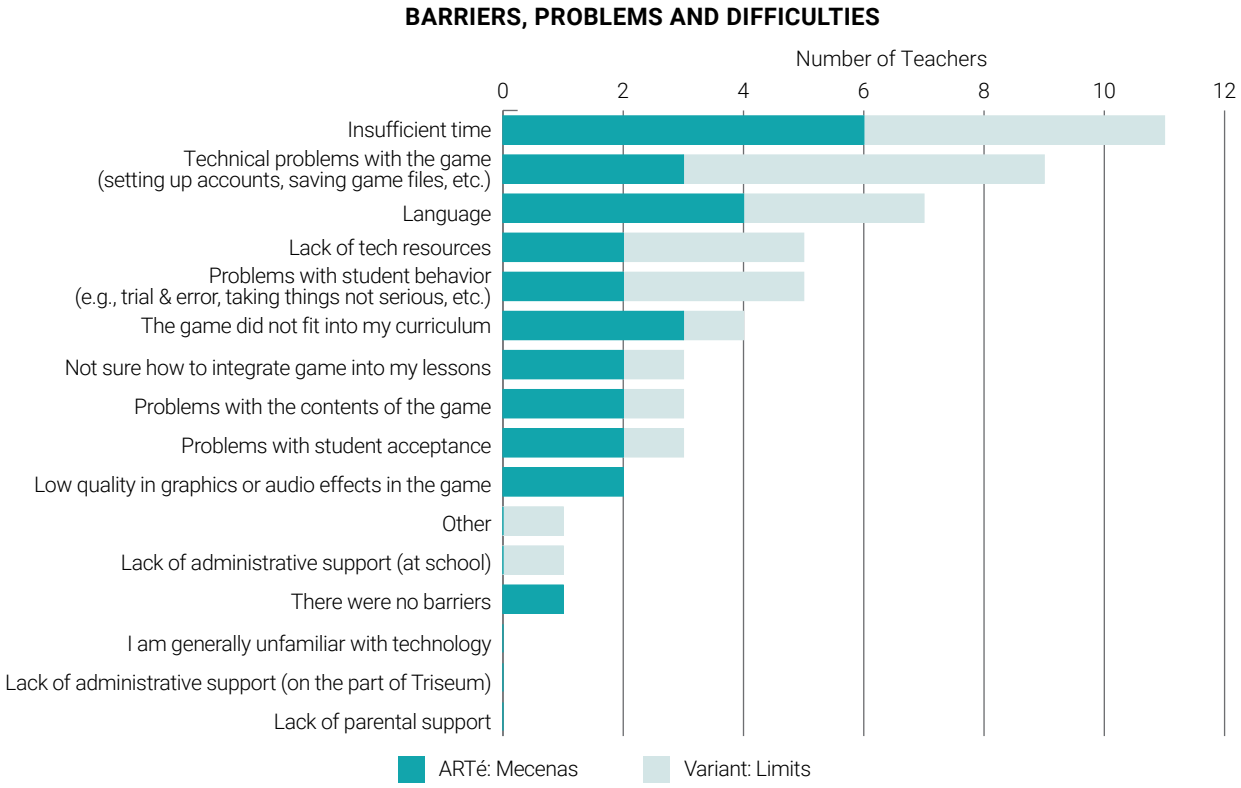


Chart 21: Barriers, problems and difficulties

3.4.7 Ease of Technical game operation

For **teachers**:

Most teachers found it "easy" (9) or even "very easy" (5) to operate the game. However, some teachers also assessed the technical operation of the game as "neutral" (3) or as "hard" (3). The distribution is comparable across both games and hints at contrarious receptions of this matter (cf. chart 22), which might be connected to the lack of experience with computer games of some teachers (cf. 3.1).

For **students**:

Most teachers considered it "easy" (13) for their students to operate the game technically (cf. chart 23).

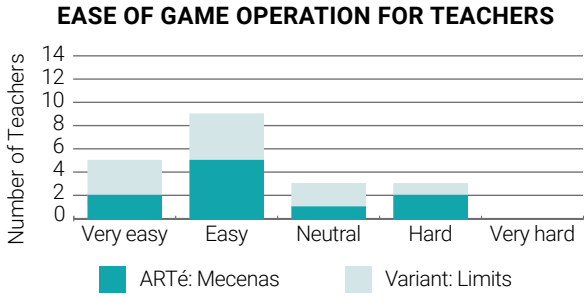


Chart 22: Ease of technical operation of the game (teachers)

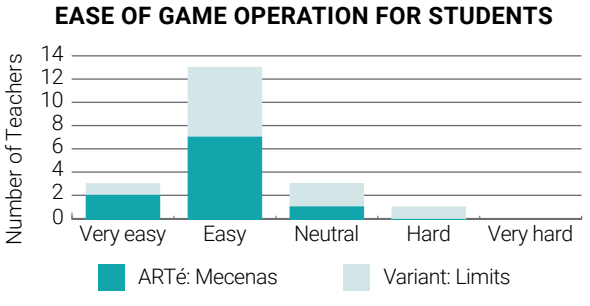


Chart 23: Ease of technical operation of the game (students)

3.4.8 Ease of game integration

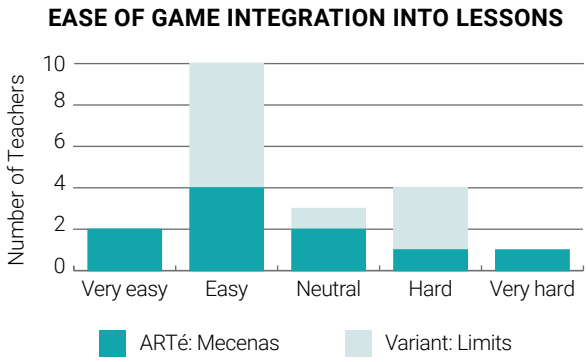


Chart 24: Ease of game integration into lessons

The distribution of answers is widespread here, especially in case of ***ARTé: Mecenas*** where answers range from "very easy" to "very hard" (cf. chart 24).

3.5 Effects on Students

3.5.1 Motivation

In the posttest, teachers answered a number of statements on the impact of game-based learning on their students' motivation. The scale ranged from "strongly agree" to "agree", "neutral", "disagree" and "strongly disagree". For the calculations as indicated in the following, these ratings were converted to numbers from 5 (strongly agree) to 1 (strongly disagree). Hence, higher numbers indicate stronger overall agreement. All average means ($\bar{x}$) and standard deviations (SD) can be found in table 3.

All in all, the results show that the teachers confirmed all aspects of motivation as defined by the underlying ARCS model (Keller, 1987). Overall, the games were perceived as having a particularly high impact on attracting the students' attention and giving them a feeling of confidence.

It is noteworthy that all average values from ***Variant: Limits*** are slightly higher compared to the values from ***ARTé: Mecenas***. This leads to the conclusion that the teachers from the ***Variant: Limits*** test group attributed a slightly higher motivational impact to their game, compared to their colleagues who worked with ***ARTé: Mecenas***.

Table 3: Impact on motivation

Item	$\bar{x}_{total}$ (SD)	$\bar{x}_{ARTé: Mecenas}$ (SD)	$\bar{x}_{Variant: Limits}$ (SD)	Component
The game had a positive impact on my students' motivation.	4.1 (0.77)	3.8 (0.75)	4.4 (0.66)	
I think that my students found the interface design of the game eye-catching.	3.75 (0.94)	3.4 (0.92)	4.1 (0.83)	Attention
*I think that my students found the design of the game vivid and appealing.	3.9 (0.99)	3.7 (1.19)	4.1 (0.7)	
	3.83 (0.97)	**3.55 (1.07)**	**4.1 (0.77)**	**Attention - total**
I think that my students enjoyed the game so much that they wanted to know more about the topic.	3.5 (0.67)	3.4 (0.66)	3.6 (0.66)	Relevance
I think that my students found the contents of the game useful to themselves.	3.8 (0.6)	3.7 (0.46)	3.9 (0.7)	

Item	$\bar{x}_{total}$ (SD)	$\bar{x}_{ARTé: Mecenas}$ (SD)	$\bar{x}_{Variant: Limits}$ (SD)	Component
	3.65 (0.65)	**3.55 (0.59)**	**3.75 (0.7)**	**Relevance - total**
*I think that my students did not find the activities in the game too difficult.	3.85 (0.96)	3.6 (0.92)	4.1 (0.94)	Confidence
*I think that my students could understand most of the material in the game.	3.8 (0.81)	3.6 (0.92)	4.0 (0.63)	
	3.83 (0.89)	**3.6 (0.92)**	**4.05 (0.8)**	**Confidence - total**
I think that my students learned some things that were surprising or unexpected with the game.	3.85 (0.48)	3.8 (0.4)	3.9 (0.54)	Satisfaction
I think that the wording of feedback after the exercises, or of other comments in the game, helped my students feel rewarded for their effort.	3.65 (0.85)	3.5 (1.02)	3.8 (0.6)	
	3.75 (0.7)	**3.65 (0.79)**	**3.85 (0.57)**	**Satisfaction - total**

*Item was reverse-coded

3.5.2 Classroom Engagement

The teachers answered a number of statements on the impact of game-based learning on the students' classroom engagement in the posttest. The scale ranged from "strongly agree" to "strongly disagree", and the calculations were performed with the same method like in case of motivation (cf. table 4). Hence, again a higher number means higher approval of the according statement.

The overall results indicate that both games were mostly perceived as increasing the students' classroom engagement. Out of the four types of engagement that were focused, the games had the strongest positive impact on emotional and agentic engagement. The impact on cognitive engagement was perceived as comparably low, but still overall positive. Again, the mean values for *Variant: Limits* are consistently higher, suggesting that *Variant: Limits* had a somewhat stronger positive influence on the students' classroom engagement as compared to *ARTé: Mecenas*.

Table 4: Impact on classroom engagement

Item	x_{total} (SD)	$\bar{x}_{ARTé: Mecenas}$ (SD)	$\bar{x}_{Variant: Limits}$ (SD)
The game had a positive impact on my students' **behavioural engagement** (e.g., they showed high on-task attention and concentration, high effort, and high persistence, especially on difficult tasks).	4.0 (0.84)	3.9 (0.83)	4.1 (0.83)
The game had a positive impact on my students' **emotional engagement** (e.g., they showed frequent and strong positive emotions (interest, joy and curiosity) and infrequent negative emotions (anger, boredom and discouragement).	4.2 (0.75)	4.0 (0.89)	4.4 (0.78)
The game had a positive impact on my students' **cognitive engagement** (e.g., they used sophisticated learning strategies, were planful and strategic learners, and monitored, checked and evaluated their work).	3.65 (0.79)	3.6 (0.8)	3.7 (0.78)
The game had a positive impact on my students' **agentic engagement** (e.g., they offered suggestions, asked questions, expressed interest, preferences, and likes vs. dislikes).	4.1 (0.54)	4.0 (0.45)	4.2 (0.6)
ENGAGEMENT TOTAL	**3.99 (0.77)**	**3.88 (0.78)**	**4.1 (0.73)**

4.5.3 Content Knowledge

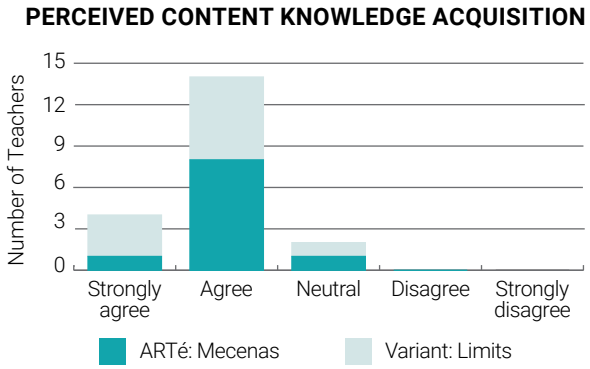


Chart 25: Perceived content knowledge acquisition

The teachers were asked for their agreement with a general statement on their perception of their students' content knowledge acquisition with respect to the games and game-based learning.

A majority of 18 teachers supported this statement, while two teachers selected "neutral" as their answer (cf. chart 25).

3.5.4 Acceptance and interpersonal differences

In addition to the general question on the students' content knowledge acquisition, the teachers were also asked for issues of acceptance and for interpersonal differences in the effects of the game-based learning approach. Table 5 includes all average values and standard deviations, following the same methodology as above.

It is an important result that the overall acceptance of the game was quite high: teachers reported that most students were described to like the game. Again, the average value for ***Variant: Limits*** is considerably higher.

Notably, the teachers described that ***ARTé: Mecenas*** clearly had higher effects on stronger students, while with ***Variant: Limits***, weaker students were described to benefit more strongly. To most teachers, there are no clear differences between genders. With regards to gaming experience, it seems that ***ARTé: Mecenas*** is particularly appropriate for students with frequent gaming experience.

Five teachers noted down additional effects:

- "Discussion, Reflection, Self-assessment"
- "boys are more inclined to play, whereas girls are more willing to a frontal teaching"
- "I observed weaker students to enjoy the game. I also observed students weaker in History and stronger in Math to change attitude in my History class by passing the levels rapidly. This made me assess them positively- a fact that enhanced their self-esteem."
- "Some students showed very good technological skills, and students who are always distracted and inattentive in the students were very participative in the classes with the game, they collaborated and helped the classmates, which was a surprise for me."
- "Learning curriculum next classes"

Table 5: Aspects of acceptance and interpersonal differences

Item	$\bar{x}_{total}$ (SD)	$\bar{x}_{ARTé: Mecenas}$ (SD)	$x_{Variant: Limits}$ (SD)
My students acquired social/communication skills from the game.	3.75 (0.77)	3.8 (0.87)	3.7 (0.64)
Most of my students liked the game.	4.3 (0.78)	4.0 (0.77)	4.6 (0.66)
Weaker students benefited greatly from the game.	3.95 (0.97)	3.5 (1.02)	4.4 (0.66)
Average students benefited greatly from the game.	4.0 (0.71)	3.8 (0.87)	4.2 (0.4)
Stronger students benefited greatly from the game.	3.8 (0.93)	4.3 (0.78)	3.3 (0.78)
Boys benefited greatly from the game.	3.45 (0.86)	3.5 (0.81)	3.4 (0.92)

Item	$\bar{x}_{total}$ (SD)	$\bar{x}_{ARTé: Mecenas}$ (SD)	$x_{Variant: Limits}$ (SD)
Girls benefited greatly from the game.	3.45 (0.74)	3.7 (0.64)	3.2 (0.75)
Students who are frequent gamers benefited greatly from the game.	3.68 (0.98)	4.1 (1.04)	3.2 (0.63)
Students who rarely or never play games benefited greatly from the game.	3.45 (0.74)	3.4 (0.74)	3.5 (0.5)

3.6 Future perspectives and overall rating

3.6.1 Future perspectives

Asked for future perspectives, all teachers in the study confirmed that they would recommend the game to a colleague. Also, a convincing majority of teachers (18) intends to use the game again in the future (cf. chart 26).

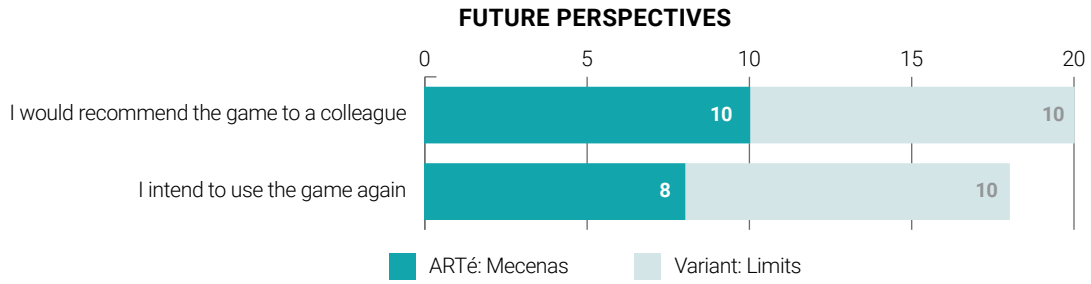


Chart 26: Future perspectives

3.6.2 Teacher suggestions for improvement

The pilot project teachers described various ideas related to the improvement of their games, both regarding technical aspects and regarding the contents. In the following, these recommendations are summarized, again grouped (where applicable) according to inductively derived categories:

ARTé: Mecenas: Suggestions related to **technology**

- Mobile version (2)
- Better resolution in Mac version (1)
- Local translation (1)
- Features for a more realistic impression of being a person of that historical period (1)
- More interactive features, e.g. pop-up videos (1)
- Better working scoring system (1)
- Game mechanics: Digital game with an Italian city from the time with characters (1)

ARTé: Mecenas: Suggestions related to **content**

- More content beyond the Italian Renaissance (4)
  - Less art, more politics and culture (1)
  - Not only Italian Renaissance (1)
  - Not only Renaissance (1)
  - Other epochs than Renaissance (1)

- More variation (2)
  - in tasks (1)
  - in different scenarios (1)

- Historical intro, as an immersive short narration describing the historical time through describing the main characters (1)
- List of all paintings and names mentioned (1)
- Additional information about the social context in which the game takes place (1)
- Interpretation of artworks (1)
- Better explanations (1)

Variant: Limits: Suggestions related to **technology**

- Cloudsaves (5)[2]
- Possibility to access specific puzzles (2)
- Automatic saving (1)
- Possibility to go backward (1)
- Win32x (1)
- Multiplayer mode (1)
- Local translation (1)

Variant: Limits: Suggestions related to **content**

- Creating own puzzles (2)
- Random puzzles generator (1)
- Possibility to manipulate the difficulty (1)
- More help for some levels which are difficult to solve (1)
- Less text (1)
- Additional context (2)
  - limits evaluation (1)
  - calculations of limits (1)
- Questions in each zone (1)

3.6.3 Overall rating

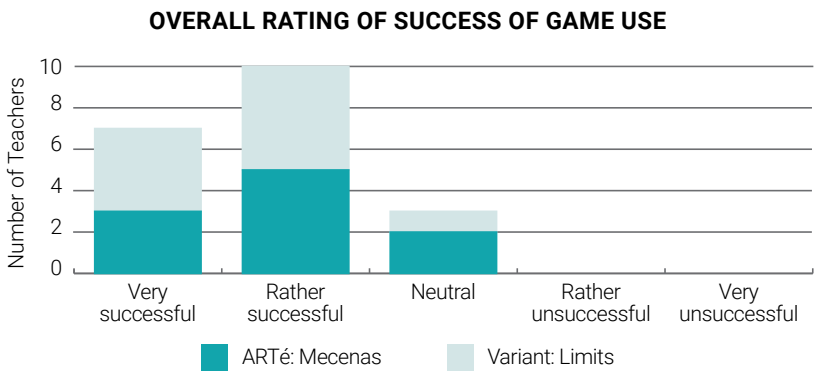


Chart 27: Success of game use

The teachers were asked to give a comprehensive overall rating of the success of the game-based learning approach with the two games. As chart 27 shows, the overall rating is positive. There is no teacher who considered the game "rather unsuccessful" or "very unsuccessful". On a scale from 1 (very unsuccessful) to 5 (very successful), teachers rated the game with 4.2 on average (SD = 0.68). The teachers who worked with ***ARTé: Mecenas*** rated their game with 4.1 (SD = 0.7), while the teachers who worked with ***Variant: Limits*** rated their game with 4.3 (0.64).

2 Based on the teachers' feedback from the evaluation study and other adoptions, Triseum™ released version v1.1.5 of Variant: Limits in May 2018 with cloud saves included.

Explanations of rating:

Table 6 presents the explanations that the teachers provided for their rating as summarized in chart 27.

Table 6: Explanations of rating

Rating	Game	Comment
"very successful"	ARTé: Mecenas	"As it was my first experience with games - that was very good." "Most of my students from 3 grade finished the game. I think that ARTe: Mecenas is better for my older students" "Students not only played the game, but are engaged in other creative activities as well (video making, creative writing etc.)"
	Variant: Limits	"The students were very motivated, and were a lot better prepared for the following subjects and concepts in the class, building on the content and concepts covered in the game. e.g. working with differentials." "playing encouraged weaker students to practice more and helped to feel comfortable with the topic" "greater commitment and interest, higher achievements in tests"
"rather successful"	ARTé: Mecenas	"Students reached 4th level easily; many of them go on at the first and second level. The time of each level was a problem for some of them." "It has been rather successful because I see that using games creates collaborative and investigation learning among the students. It will be very successful in the next class when I have implemented more learning materials to the game." "the game was great, I have to improve in projecting the combination between gaming and frontal teaching" "Students learned quite a lot about the Renaissance. This historical period is not included in the curriculum of the 10th grade. Despite that they enjoyed working in the project and playing the game. They found interesting the comparison between art in Ancient Greece and in the Renaissance." "The students appeared motivated, interested and curious. They have therefore improved their ability to understand the English language and to know how to orientate itself even when not all words were known. They have also acquired a good visual memory of the works and are now able to recognize the historical context, even if not always to classify the subject and the author."
	Variant: Limits	"The game helps students create geometrical representations of limits. They can relate to what limits are after less training time than with just „traditional" learning material." "Students who have more difficulty in math, in assessments of limits and continuity have had better results, and that students' motivation to learn has improved greatly." "My students liked this game very much. I could use a new tool which support learning process." "No student has finished the game yet." "It depends on the point of view. Generally, my impressions are very positive"
"neutral"	ARTé: Mecenas	"I think a lot went well, but I see after I`d implemented the game something I would have done differently." "The students that played the game gave me feedback along the way and realized that, even though it had interesting aspects (like the collaborative work and the decision making process) it didn't quite reach their expectations."
	Variant: Limits	"Too many organizational problems. If I'd known about the project before the school year I could prepare a place to use the game only in the school."

4. FOCUS GROUP ANALYSIS: ARTÉ: MECENAS™

4.1 The impact of ARTè: Mecenas™ on student motivation

According to the motivational conditions as defined by the ARCS model (Keller, 1987), the pilot teachers addressed the following aspects :

4.1.1 Attention

There is evidence that the game-based learning attracted students' attention.

This is also due to the processes of **inquiry** that the students were offered, meaning that they had to be creative and find solutions on their own (inquiry-based learning):

> ***"To take the right decision, they realize that they have to gain the right knowledge, and they have to find it in the handbook, or in the slides, or on the Internet, and so it's a combination."***

Humor and **fun** were also relevant with this regard:

> ***"So it was quite fun."***

This is of central value because fun is of particular importance for games, even beyond increasing attention as its function is defined within the ARCS model. As Prensky (2001) summarizes, there is evidence in literature that fun helps brains function more efficiently and learn better (p. 111).

Furthermore, the aspect of **variability** was addressed, which means that the game helped varying and amending traditional teaching and learning processes:

> ***"Maybe they also take into account that they have five or six hours of frontal lessons, so when you give them an alternative, they're really willing to do that."***

The game mechanics also helped to attract some students' attention, as the following quote shows:

> ***"Some enjoy the game mechanics."***

This remark is particularly interesting because the game mechanics were also described as a problem or a demotivating factor for others, as will be shown in chapter 4.1.6. Obviously, game-based learning has various effects on students.

4.1.2 Relevance

Some cases were reported in which the game or game-based learning, either in its content or format, was perceived as **relevant to the students' interests**, to their **experience**, and to **things they know**:

> ***"Some just when you want to say the name, when you just explain that we're going to play a game some it's already sold […] on the concept, you don't have to say anything else."***

The process of **modelling** was also a central element that teachers chose for giving the students a feeling of relevance. Modelling in this context is understood as encouraging students to function as tutors (peer-to-peer instruction) and to help their peers in contexts they are more proficient at.

> ***"So, there is for every team a student to explain it as how to play and of course the rules and the way to reach the scores."***

4.1.3 Confidence

Fewer remarks attested the impact of the games on students' confidence. With *ARTé: Mecenas*, they are limited to the aspect of increased **self-confidence**:

> ***"[A student] was the best, and he really was proud, and so I motivated him to handle the students, and I can see that he felt very well because of this situation that he was the best."***

4.1.4 Satisfaction

According to the teachers' descriptions, the Triseum educational games gave students a feeling of satisfaction.

This perceived satisfaction also stemmed from the observation that the game had **positive outcomes** for the students, which addressed different levels. Two examples of such outcomes are a feeling of success and achievement, and positive feedback:

> ***"If you have students that are gamers, and maybe not so good in general at school, because of reading or writing, they will get a positive experience out of the game, because how you succeed, or how you use the game or play the game can give you a high score. You don't always have to have the knowledge that's required to get a high score."***

> ***"Some of my best performers in the game are not the best students, so it's good to give them positive feedback, to me. Otherwise, I don't have any chance to say, 'You're a good student.'"***

Also, the accomplishment of the game or of game elements gave the students a **good feeling**:

> ***"They were very proud of it."***

> ***"They feel respected in a whole… On another level because they used so much time."***

4.1.5 Further aspects

There was another aspect mentioned by the teachers which is important but does not directly relate to the ARCS model. This aspect is **collaboration**, and it also helped increasing the student motivation:

> ***"They enjoyed the chance they had to collaborate with other."***

Overall, the examples given above serve as an indicator for the motivating potential of the game and game-based learning. All of the four conditions of motivation as defined by Keller (1987) have been addressed and described by the teachers to a varying degree, and general remarks on the motivational potential and aspects that go beyond the ARCS model prove that a motivating effect can be assumed from game-based learning instruction. Yet, there were also critical voices regarding the motivational potential of ***ARTé: Mecenas***, which will be introduced in the following.

4.1.6 The role of demotivation

A number of statements were recorded which present contrary opinions and indicate that ***ARTé: Mecenas*** was not motivating for all students or even had demotivating effects. However, it has to be pointed out that a motivating effect on all students could not be expected, because the groups of learners are heterogeneous and individuals naturally respond to different methods.

Failure and frustration

Frustration significantly impedes a gamer's motivation to play. Is has been described by the concept of ***Flow*** (cf. Csikszentmihalyi, 1990) that a mental state of intense concentration is reached when the challenges within a game and the gamer's ability to solve these challenges are perfectly matched. Otherwise, a gamer will be bored if a game is too easy, or frustrated if it is too hard. In both cases, the gamer can be assumed to stop voluntary gaming sooner or later (Prensky, 2001, p. 124). Teachers in the pilot project indicated that frustration occurred with some students:

> ***"Some of them were very frustrated because they didn't pass the first level or the second level. When they lose, okay? When they reached 39 points — just one [more] to get [to the next level]… They got totally angry, but that's learning by making mistakes."***

Game mechanics

Further remarks regarding demotivated students were related to the way the game is designed, and to its mechanics. The core of this criticism relates to the text-based format:

> ***"This thing about leveling up isn't for everyone. It isn't motivating for everyone, and for some students, the game actually can be a little bit… It can be a little bit too similar to just using textbooks, because it is a lot of reading, and that sometimes demotivates the students, because they think, 'Okay, it's a game,' and then it's not so much of a game as they are maybe used to."***

Generally, the consideration of motivational and demotivational potential leads to the conclusion that ***ARTé: Mecenas*** combines both, depending on a variety of factors. The following two factors have an impact on the direction the motivation or demotivation may take: interpersonal differences (e.g., gender, gaming experience, general student performance), and the way of implementation (e.g., learning activities, social settings). The interpersonal differences will be explored in chapter 4.3, while the ways of implementation are analyzed in greater detail in chapter 4.4.

4.2 The impact of ARTé: Mecenas™ on student classroom engagement

4.2.1 Behavioral engagement

The teachers in the study indicated that their students showed behavioral engagement when playing *ARTé: Mecenas*.

More specifically, students put **high effort** into their practice:

> ***"They feel engaged, and they put effort into gaming, and in learning, and in looking for information."***

When playing, their **on-task attention** was high:

> ***"When you use the game, the very best thing is that when you use it in a session, a lesson, the students actually use their time on the game. If you play a game in 60 minutes, the students will play for 60 minutes, and in many other forms of teaching methods, you don't actually get that good of a response from the students."***

Some students also demonstrated **high persistence**, especially on difficult tasks:

> ***"Because they liked it and some, one of the girls that was a little bit skeptical at first, she has actually used a free time, she had a break at school. And so instead of just going down to McDonald's […], she just chose to play the game because it was a better alternative."***

4.2.2 Emotional engagement

The teachers also described having witnessed emotional engagement with their students, most centrally because the students showed **frequent and strong positive emotions**:

> ***"They're really happy to go to the technology lab."***

4.2.3 Cognitive engagement

Fewer evidence was mentioned regarding the students' cognitive engagement, like in the following example:

> ***"Sometimes they're driven from their knowledge about history that they have done."***

4.2.4 Agentic engagement

Teachers observed that their students demonstrated agentic engagement in various ways.

More specifically, the students **asked questions** and **offered suggestions**:

"Some students said, 'In the beginning we don't know what are you discovering? How can we discover?'"

"I mean they look for, they try to ask, they try to find a way to resolve the problem."

They also **expressed interests, preferences,** and **likes or dislikes**:

"After the lesson she told me, 'That was very nice, I really enjoyed that'."

All in all, each of the four aspects of classroom engagement was addressed. As in case of motivation, it was also mentioned repeatedly that the effects that could be observed in terms of classroom engagement differed between students. This makes it difficult to summarize, because summaries always tempt to suggest a genuine applicability. For the consideration of the results, it should be kept in mind that there were also students who did not or only rarely show engagement as described above. Yet, the results show evidence of a positive influence on students' classroom engagement, with some limitations or caveats as described. These limitations, i.e., the differences in the impact on students with different characteristics, will be explored in the following.

4.3 Interpersonal differences in the impact of ARTé: Mecenas™

Teachers mentioned a number of interpersonal differences which led to differing motivational attitudes and, as a consequence, to differing developments in the classroom engagement and in the results achieved with the game. These interpersonal differences were described to refer to 1) gender, 2) general student performance, 3) knowledge of mathematics, 4) gaming experience, and 5) age/grade.

4.3.1 Gender

As far as differences between girls and boys were concerned, some teachers attested the boys a more competitive attitude. One teacher had the impression that boys are better at game mechanics, while girls are better at considering choices:

"The boys are usually better at the game mechanics part, but the females are much better but reflecting on the choices. Males – […] if they see a good deal they will do that but then the females just said 'no, no, no, stop.' The girl just try to think this through now."

"The boys are more competitive where I am."

4.3.2 General student performance

Several teachers noted that the general performance of a student, i.e., whether he or she generally is a weak or a strong student, has an impact on the performance with the game, because stronger students have more successful experiences and perform better:

"For best students that really master the game I think it's a really good effect, but for those that keep on failing level one for instance, they have the complete opposite approach, because then the game suddenly feels stale because they can't go further. So that means that they have a bad experience and they just keep repeating mistakes and if they don't understand, even though if you try to explain. If they don't manage to visualize their mistakes then the game gets

repetitive for them. […] So I think for the weaker students that don't master the game I think doesn't have a good experience."

4.3.3 Liking Mathematics

It was mentioned twice that students who like mathematics tend to like the game as well and be successful with it:

"One thing that surprised me — it's not only the difference between boys and girls, but we have a difference between people that […] like humanities and maths. These kinds of lessons. This game appeals to both, and some of the students that like maths and geometry said, 'I was surprised when I found out that I liked the game. I didn't expect to like it so much.' That was surprising for me."

4.3.4 Gaming experience

It has also been expressed that prior gaming experience gives the student an advantage in mastering the game mechanics and in starting successfully:

"If you are a gamer, it's more likely to succeed fast in this game, because the game mechanics gives them an advantage."

4.3.5 Student age / grade

With regards to the age and grade, teachers made differing experiences. While one teacher found his or her younger students to be more engaged, another teacher discovered that his or her older students were more successful with the game. However, it should be noted for the interpretation of this facet that all students in the pilot project were aged between 16 and 19. Hence, the differences in age are not very large, which could be an explanation for the different teacher perceptions in this context.

"For me it's really surprising because I thought that maybe students who are second year [like it better], but the first year students are more into it."

"Particularly the older students know it in the last year of upper-secondary school — 18, 19 — they understand the game better. It takes a shorter amount of time before they get through level one and level two than the students from the first and second year, except from those that you can see have played games before."

Out of these five aspects which were described to have an impact on the effects of *ARTé: Mecenas*, the aspect of student age or grade seems neglectable because of the low variety within the test group. The gender facet is interesting in terms of different directions the effects can take, but the according comments did not indicate that either girls or boys clearly have a disadvantage for playing or succeeding with the game.

However, the following three coherences seem particularly noteworthy:

- Between student gaming experience and success within the game
- Between general student performance and success within the game
- Between liking mathematics and success within the game

It has become obvious that the heterogeneity which characterizes each group of learners to a different extent can have a serious impact on the success of the game-based learning approach. This makes it even more important to combine the game implementation with a didactically sound approach and to support the students in their gaming process pedagogically to meet the challenges of heterogeneity and enable every student to take benefit.

For teachers who intend to use ***ARTé: Mecenas*** in the future, it might also be helpful to take into account the observations that the pilot teachers made here, and to take extra measures and special care to ensure that weaker students and students who do not like mathematics can benefit from the game use as well.

4.4. Ways of implementing ARTé: Mecenas™

4.4.1 Implementation settings

Concerning the **location** of gaming, two competing models were mentioned. Most teachers described using a combination of playing at school and at home:

> ***"We have played the game for two hours only, and then I've left them, over their vacation holidays, to play it by themselves. They played it, and a great number of students finished it, and now we're going to play some more so that we can go on with our post-game activities."***

However, some teachers deliberately chose to delimit the gaming to school lessons:

> ***"To play only at school, and…because I wanted to monitor the situation, and I want them to be at the same level, at the beginning, at least, and if they will have played at home, I couldn't have control about that."***

With regards to the **social settings**, the teachers tried out and combined quite different approaches. The scenario that was mentioned the most often was pairing the students together, and several teachers preferred to compose these pairs intentionally:

> ***"Why in pairs? Because they have much more fun, and because one of them is focused on the screen, and we have two computers for the pairs, for the couple, and the other one is in charge of looking for info, to take the right decision, and to check art and politics and economics and so on."***

Another approach favored small groups:

> ***"First of all we decide to work in teams, and we decide how to compose these teams. I mean to try to resolve the problem about the English knowledge. We try to do some different teams with at least one is good in English, one […] is supposed to be good in English. One was supposed to be good in art. One was supposed to be good in Mathematics, History and so on. So, we made this composition of different teams, with different personalities and that is good, because going on, I noticed that the problems with the language are going better, because there is always somebody who understands better than others the English."***

Also, teachers described a few students who preferred to play individually:

> ***"I have two students that didn't want absolutely to work with others."***

Finally, one teacher also described playing with the whole class as one group:

> ***"We play it altogether, when we play it in class. We have an interactive whiteboard, so everyone sees. Everyone gets to make a decision, and all the others discuss this decision."***

It should be noted though that the teachers also experimented with the social settings, tried out different methods and combined approaches, like in the following examples:

> ***"In the first step it's very important to work in teams, but I think the second and the third and so on, it's very good [if] the student [plays] in the library or at home, playing the game without me. They understand how is the game if they play individual. The first step yes in pairs and to discuss it's a very important discussion, because learning is continu[ing] and it's very important to discuss and then contextualize and then play. Play individual."***

> ***"I didn't know whether to make a competition among them or not, and in one class, I tried to make a competition, and in the other one, I let them help each other: the best performers can go back and help the others. And I still don't know what's better."***

4.4.2 Teaching and learning activities

For the **introduction** of the game, the focus groups revealed that a majority of teachers chose to show and explain the students how to play frontally:

> ***"Well I began with a little presentation of the trailer of the game in the beginning, then presentation with the rules of the game, what the students needed to learn previously about before playing, the context of the renaissance."***

Concerning the **purpose** of the game in class, there were mainly two approaches: using the game as a revision of familiar knowledge, and using it to introduce new knowledge. When it was used in the context of acquiring new knowledge, teachers appreciated *ARTé: Mecenas* as fulfilling mainly three functions, which are a tool for knowledge acquisition, a tool to trigger and support learning processes, and a source of information:

> ***"I use it as a complementary tool towards understanding history and relationship between society and politics and economics."***

> ***"You basically should use the game as a tool in order to deepen the learning in addition to all the other traditional tools that you have at your disposal."***

One teacher also described using the game as a subject for the students to analyze in the sense of a media educational task:

> ***"I made an inquiry, but not specifically about that day, with questions about that day, not with questions about the curriculum, but what they think about teaching games with learning — what they think they learned more…with which method they learned more, and I made a list, and they chose why they thought they learned with that, or with that, or with that, and with games, the advantages and disadvantages. We got what they think, what they'd change if they could change it."***

These game purposes directly relate to the **teaching and learning activities** that the teachers used in the context of working with *ARTé: Mecenas*.

A first group of activities served to prepare contents and provide information needed to successfully play the game:

> ***"So, we made some pre-game activities. Based on the game, I asked them some questions. They filled out a questionnaire."***

Other activities repeated contents from the game:

> ***"I ask in a presentable way, what were you writing about the games? For instance ARTé: Mecenas and the quizzes that we do and we made with the students and then we did some equipment's to the students and what did you learn at the first level, at the second. Do you learn more about renaissance, what did the art mean to you? Several inquirements [sic] and with several levels."***

A number of activities were described that enhanced, deepened and/or amended contents from the game:

> ***"I chose Sandro Botticelli's paintings, because it is in our curriculum. So, I prepared a kind of activity card for students. The title of the activity sheet is 'Story Time,' and there are six of Sandro Botticelli's paintings in the game. So, at the beginning, they had to read about all the paintings in the game, and I gave them some tasks — I mean, for example, to write what the man tells the woman in the painting, and other activities."***

Assessment activities were also used in connection with the game:

> ***"For me, I've planned four areas of assessment. One is the level they reached, because that's not subjective. […] It gives you an idea about the way you played — if you played well. Okay. The second one is about the contents they started. In the handbook, and through my slides and so on, which is besides the game, okay? We'd already done that through that model — a quiz, open questions, and just…choose the right answer. The third area is about behavior. It's about discipline and engagement. How do they play — seriously or loosely? The fourth area is just self-evaluation and reflection about the experience. That's going to be Monday. It's through Google, the questionnaire. Okay? At the end of it, a final free discussion. 'What do you think about it? Do you suggest it for the next class? What can we improve?'"***

One type of activities described allows for a reflection on game-based learning as a teaching and learning method:

> ***"We have a constantly evaluation of how the game is perceived. We have some service with the students how they, what they have learned how - what they perceive what can be done better? Do they prefer this method, do you need to have more traditional ways of learning."***

There were also learning activities that were performed beside playing, that amended and helped the process of playing:

> ***"The other one [student] is in charge of looking for info, to take the right decision, and to check art and politics and economics and so on. I gave them the permission to go to the Internet and check, because it's part of learning by doing. Learning by searching."***

In spite of this variety of activities, one teacher favored having the students play on their own without additional activities:

> ***"I haven't given them any assessments on the playing of the game, because one of my most interesting thoughts about this game is to see — because it's a learning game — is to see if the game itself is enough for the students to actually learn what they were supposed to learn, because when I play the game, I do that."***

4.4.3 Barriers, problems and difficulties

In the focus groups, the teachers also described difficulties they faced, and problems that occurred. These will be presented in the following, grouped by inductively developed categories.

Lesson integration

Some teachers mentioned issues related to **support and acceptance**, both on behalf of the administration and on behalf of the parents:

> ***"We have some bureaucratic problems."***

> ***"I went to this classroom, to the parents' meeting, and I asked for permission from the parents during this final program, and many had some questions about it, especially about the assessment, because they were worrying about the English, and the results, and probably some parents are old-fashioned, and they are not used to these methods."***

It was problematic for some teachers to find **sufficient time** for the pilot project and the gaming within their tight schedules.

> ***"A big period, and we don't have a lot of time. They only have two 90-minute's each week, and in one year, that's a large amount of history, and not so much time."***

In this context, it was perceived as a disadvantage that the game required a lot of time for quite a small amount of content, which decreased the worth of the game for some teachers:

> ***"I have to say I don't need something like that to let them learn History. I can do exactly the same subject in two or at least three lessons. I spend a lot of time from the thing that we usually do in Italy in just two hours, because we have so much Renaissance to do."***

Some teachers expressed a problem with the **curriculum fit** of the game. It seems that in some countries' curricula, e.g. in Norway, the topic of *ARTé: Mecenas* is less relevant:

> ***"For us, the Renaissance era is a really small part of our history lesson. So […] when we present our classroom scenarios, we have the history book with us and it's three pages. That is all the kind of focus we have on the medieval times. So for us it's not the focus, really at all because we are more focused on how the Norwegian society developed from the Viking ages through to the merchants from the Hanseatic, from the Germans."***

Contrary to that, for other countries, e.g. Greece, the game does not go far enough and covers only a small part of the according contents:

> ***"Maybe the game is just a small part of what we usually do."***

Culture and language

It is closely related to these issues with the curriculum fit that some teachers also described a problem with the **cultural fit**, i.e. with the culturally shaped perspective on history the game represents.

> ***"So it depends in which country you implement the game, because in Greece for example, renaissance, European renaissance is considered to be the western history. […] Western culture. Whereas we teach medieval byzantine culture [in Greece]. So I have to make extra steps to help my students understand westernized renaissance. Whereas in Italy it's just so easy."***

A reoccurring issue is also related to **language**, although this problem and the ways to face it is highly dependent on the respective country. Teachers from some countries identified the English language of the game as highly problematic:

> ***"English is a handicap matter for our students in Portugal."***

Teachers from other countries, e.g. from Poland, however did not see a problem with the English language, or even turned the fact that *ARTé: Mecenas* is in English into an advantage and appreciated the additional learning opportunity:

> ***"No just only about the language, I think my students are quite good let's say in English. So for us it's rather like a benefit that the game in fact is in English, because you know, they have to learn something. They are using the game to learn some other similar English, so it could be also, I think it could be good for students."***

Technology

There were a number of problems that related to technology. To start with, the preconditions in terms of **technical equipment** were quite different among the countries. While Norwegian students all had their own laptop to work with, students and schools from other countries were described to be poorly equipped:

> ***"In Portugal the main problem is technology. The wireless, I don't speak about it. Always failing, always failing, always failing. Computer… The game doesn't work because wireless is not strong."***

Technical problems also occurred **within the game**. Some teachers had problems with the website and the online application of *ARTé: Mecenas*:

> ***"Yes, just download, without, I can't. After other problems, the game doesn't memorize the steps you have done before. So when you get inside either you find, there was written: 'Do you want to continue the previous game or you want to start again?' You say, 'I want to continue,' but often, it doesn't memorize what you have done. So you start again."***

In some cases, students seemed not to be **familiar** (anymore) with playing a computer:

> ***Teacher A:*** *"It's quite odd for students to play by computers. Yeah, for us it's normal."*
> ***Teacher B:*** *"Computer is old fashioned."*

Students

Student behavior also caused problems in a number of incidents.

There were students who did not like or even plainly refused to play:

> ***"This class is a pre-university entrance exams class, so some of these students were... They did download the game, but they didn't play it."***

Other students showed problematic behavior:

> ***"There's just one pair of two students that actually has failed the game completely, from typing the username and getting the username right — problems with that — and just managed to get through the tutorial, and just not getting anything right in level one. There was just two students out of maybe 100 students that that happened to. […] It's about the concentration. They didn't want to concentrate."***

Game mechanics

Some teachers described problems within the game. A majority of these problems are related to the **game mechanics**, and to the way that *ARTé: Mecenas* works. In chapter 4.1.6, it has been described that this led to demotivation in some cases. Furthermore, there were cases where the game mechanics bored or disappointed students:

> ***"A big part of the students got tired of the game mechanics, because it's always the same, you know. Reading, decision, reading, decision."***

> ***"I think many of our students actually think that they're going to be entertained when you say, 'Okay, we're going to play a game,' and then, 'Oh, yes. Finally, something cool,' and when you progress in the game, it's… Yeah. They think, 'Is this it? Is there anything else?'"***

All in all, these observations regarding the ways of implementation show that the teachers in the pilot study chose a variety of game-based learning approaches. It has become clear that the preconditions vary and are strongly dependent on the cultural and national background of the teachers, which result in different perceptions and in individual problems. Problems which are related to culture and nationality most centrally include curriculum and cultural fit, the perception of the English language use in *ARTé: Mecenas*, and the students' technological equipment. Yet, the teachers came up with unique and creative ways of meeting their conditions and requirements and found ways to cope with problems to make most of the game use.

With regards to meeting and overcoming the problems for future uses of *ARTé: Mecenas*, there are various approaches. Some of the aspects mentioned could be addressed by the game developer, such as addressing technical problems within the game, improving the game mechanics, and offering translations for certain countries. Other problems are not as easy to solve, but might be considered by teachers, such as problems with student behavior. A third category of problems are quite hard to influence as they relate to outer circumstances, like the ones related to culture and nationality. It can be assumed that the curriculum fit in particular, which has been shown to vary significantly, will have an impact on the future use and purchase of *ARTé: Mecenas* in European countries.

4.5. Teachers' suggestions for improvement

It should be noted that this chapter covers only the suggestions for improvement which the teachers mentioned when specifically asked for their respective ideas. Further potential for improvement may be drawn from the description of problems and difficulties in chapter 4.4.3, which is therefore closely related to the following considerations.

The comments in this category either refer to technical aspects or to the game mechanics and contents.

4.5.1 Improvement with regards to technological aspects

There were basically two technology-related suggestions for improvement, one concerning **mobility** and one concerning **administrative options** for teachers:

> ***"I think it will be nice to have it in mobile."***

> ***Teacher:*** *"One thing I will need is to get all the data from the game experience, automatically, from the students. Do you understand what I mean? […] To get all the information. Instead of asking, having a kind of report."*
> ***Moderator:*** *"An administration report."*
> ***Teacher:*** *"Yeah. Which levels, how long for, and some data to understand the learning experience, and how much they dedicated, and something to be assessed."*

For assessing this quote, it should be noted that *ARTé: Mecenas*™ does offer an instructor portal, which the teacher may have missed. Hence, the potential for improvement in this case is actually not about technical amendments but about improvements in the teachers' training and preparation, because the teacher does not seem to have been aware of the instructor portal.

4.5.2 Improvement with regards to game mechanics and contents

Most comments in this category related to the **addition of interactive and vivid elements** to the game, such as short video clips or pictures to give an alternative to the text-based and static basic interface of the game (cf. chapter 4.4.3):

> ***"What I would like was, sometimes, when they make a decision, boom, there comes a picture or a small video that — [crosstalk] just visualizing what you actually did, but you can't do that, because the questions are more or less the same — not in the same order, but if you find something that you could add, more visually, to the game, I think the students won't find it so repetitive all the time."***

These ideas can be related to principles of game design. As Prensky (2001) describes, it is a genuine feature of good game design to have energy: "This comes from things such as movement, momentum, and pacing. The game's energy is what keeps you playing all night or rejuvenates you after a hard day" (p. 134). So, an interpretation of the teachers' input here is a claim for more energetic elements within the game, and it seems desirable to add interactive and vivid elements to amend the static interface and to bring some variety and increase attention. In this context, it was also asked for more variety in tasks and scenarios in the posttest, which might be another starting point for increasing variability and interactivity.

One suggestion is made about translating the game to native **languages** (cf. chapter 4.4.3):

> ***"I think in the native languages version in maybe Portuguese or the other language is very good."***

As all other remarks related to language, this one should be evaluated critically, because it has been shown that other teachers considered the English language an advantage and created learning scenarios that combined language and content learning (CLIL). Hence, the requirement of local adaptions seems dependent on the specific teaching context.

There are also teachers who would appreciate additional material to come along with the game:

> ***"I was thinking now, maybe it would be good to have a supportive material given by group. Supporting material written by a specialist. Historians, economists. So each of us teacher can use this output of material to support. As a background knowledge. I think it would be good to have in the future."***

4.6. The impact of ARTé: Mecenas™ on student content knowledge acquisition

The teachers in the study mentioned a number of facets of content knowledge that the students acquired.

4.6.1 Content knowledge as defined by the NCSS

With respect to the US National Council for the Social Studies' (NCSS) curriculum standards for (NCSS, 2010), the following aspects were addressed:

Culture & Diversity

"The most important part about the game is about the artwork […]. They can at least see some artwork, and then maybe try to choose an artwork, or an artist that they like, and then dig a little more to find out some more about him."

Global connections

"We always oversimplify history, and we give them just, 'This is the cause. This is the effect. This is a chain.' No. It's not a chain. It's always decision-making, always troubleshooting, always interpreting the situations. I say to them, 'Let's think about history as, instead of as a chain, as an open circle of situational data to be interpreted by mentality, and by needs, and by the possibilities you have as an historical character. Then, you have to make decisions according to your limits, possibilities and mentality. Then, there are new situations you are creating.' That's exactly what happens in the game. So, it's a good history life experience, okay?"

Development and Identity

"When they play, they understand that in real life, we are, everybody, a political, economical, cultural, social animal. Everybody. Those phenomena are not isolated. Every day, I must make social decisions. I am a cultural being. I am a political being."

Individuals, Groups and Institutions

"They can talk about the church, and maybe some political situations about the states."

Power, Authority and Governance

"The most positive point, to me, in terms of history knowledge, is making them understand the complexity of power playing, because you cannot get the idea about that complexity just by reading the book."

Production, Distribution and Consumption

"I think they can talk about the economics."

Time, Continuity and Change

"I also think they develop a conceptual understanding of the period more than facts, I think they more understand what the period is all about."

4.6.2 Knowledge beyond the NCSS

The teachers also described the acquisition of content knowledge beyond the knowledge fields predefined by the NCSS (2010), most centrally in relation to **English language skills**, which is consistent with the Culture and Language Integrated Learning (CLIL)-approach that some teachers described:

> ***Teacher A***: *"For us it's a rather like a benefit that the game in fact is in English, because you know, they have to learn something. They are using the game to learn some other similar English, so I think it could be good for students. And also they practice reading, yes."*
> ***Teacher B***: *"Yes, it's an opportunity."*
> ***Teacher A***: *"So, it could be a problem but on the other hand it could be a good opportunity for students to get to know more."*

A number of statements also referred to the acquisition of **procedural knowledge**, e.g. with regards to **digital skills** or to **learning strategies**:

> ***"The game was a way to find questions. 'What do I not know? I don't know about the issues, the relationships, between the cities, the countries.' Now, it's a way to start digging, and finding these questions."***

As a conclusion, there is evidence that ***ARTé: Mecenas*** had a positive impact on the content knowledge acquisition of students. The teachers described that their students learned things within the fields that were to be addressed by the game and beyond.

5. FOCUS GROUP ANALYSIS: VARIANT: LIMITS™

5.1. The impact of Variant: Limits on student motivation

With regards to the ARCS model (Keller, 1987), all four aspects of motivation were addressed, as will be shown in the following.

5.1.1 Attention

The teachers appreciated the **student participation** and hands-on experience that *Variant: Limits* offered:

> ***"When you teach about limits, you can help them to calculate the limits of a particular point, and in an average class, what you do next, or at the beginning? You just draw a graph, and the game is very useful […]. Instead of drawing the graph, they can use it by themselves."***

Also, the students were given the chance for **inquiry** (inquiry-based learning):

> ***"They don't have the theory or concepts, but they have to inquire what it is. They investigate. They explore."***

Humor and **fun** were also central for the attraction of students' attention:

> ***"I think playing the game made them enjoy it more, especially for the weaker students, but for most of them, if not all."***

The **design of the game** helped attracting attention, because it was perceived as eye-catching, as vivid and as appealing:

> ***"The graphical representations in the game are really good. That helps the weaker students as well, I think."***

Also, the students enjoyed the **variability** of learning methods that the game introduced:

> ***"My best part is that it was, for them, something completely different from their previous experience."***

5.1.2 Relevance

Teachers documented in a number of statements that the game was relevant for their students.

One measure that specifically affected the feeling of relevance for the students was **modeling** (peer-to-peer instruction), which was mentioned several times:

> ***"In my mind, the students that they are in the same group will be the mentors of other students in their first year of high school. When we go to the functions that are in the curriculum, I will give these students the opportunity to present the lesson to other students. This gives extra points, I think."***

It is also described that the **students enjoyed the game so much that they wanted to know more**:

> ***"[The students] have asked, several times, 'Are we going to play today? Are we going to play more? When are we going to play again?' So, you see that they want more and that they really like it."***

In this context, it is also remarkable that the game in its format addressed the students' **experience** and **interests**:

> ***"I didn't realize how much the students are really playing games at home of totally different kinds."***

Furthermore, playing *Variant: Limits* **matched the students' needs**:

> ***"Three hours in a row, it's tough to get their attention, so I booked the IT lab for the very last hour of every Saturday, and they were so happy. So happy to go to the IT lab and play and discuss."***

Remarkably, the students themselves also **considered the content relevant**:

> ***"There are students who, when I suggest or make the proposal to join the group to play the game, tell me, 'Sorry, teacher, we don't have time because we have many lessons.' I don't press them. I don't tell them anything, but after one week, while they are listening to the feedback for other students, they came to me and said, 'Please, teacher, give a code to join the group. I think it will be very helpful for me.' Now, they really thank me."***

5.1.3 Confidence

The teachers indicated that game-based learning and *Variant: Limits* positively impacted their students' confidence in various ways.

Most centrally, the game helped their students gain **self-confidence**:

> ***"They were not asked to play, but I had one student who started to play it during the Christmas break, and he almost got to the end. He […] was so proud of himself that in the checkpoints each week, he was just going around like a peacock: 'do you need help?' […] It was really his moment, and when he finished up with the summative assessment, he almost got 10 over 10. Yeah. Usually, he is just so-so. In between passing and failing. It was really his moment."***

It was also mentioned that the **difficulty** of the gaming elements was appropriate, which is another factor for building confidence:

> ***"The game is quite simple to start. It's not really complicated, gaming-wise, which is good, of course."***

This teacher's quotation also shows that the game follows the game design motto *easy to learn, hard to master*, which has been described as being at the foundation of designing successful games (cf. Prensky, 2001, p. 135).

5.1.4 Satisfaction

Variant: Limits was perceived as a motivational plus because it gave the students a feeling of satisfaction.

More specifically, completing exercises gave them a **satisfying feeling of accomplishment**, and it **felt good for them to successfully complete the game**:

"Being about the game was a plus, because they could share the fact that they had succeeded in answering a special puzzle, or they had succeeded in getting over a special part of the game, and they wanted to show it to their colleagues. So, doing these videos was a sort of confirmation for them: 'I made it this far, and I can explain to you how I made it this far'."

It was also remarked that the students acknowledged the **positive outcomes** that resulted from the game implementation. These positive outcomes addressed different levels, like the grades but also the classroom atmosphere:

> ***"When we climbed up the stairs from the IT lab where we had the test to the classroom, they were all so thrilled, and the weaker students were two girls which… Usually they struggle to get good marks, and almost always they do not get good marks, and they were so thrilled. So, all on the staircase — 'Yes, yes! It was the game, because we practiced a lot!' So, it's true. It helped the weaker ones very much.***

In this context, it is an important observation that *Variant: Limits* was repeatedly reported to have a positive influence on the classroom atmosphere and on the relationship between teachers and students:

> ***"I would like to say also that, during the implementation of this game, I get very close. I change better collaboration with the team of students. We are not like teacher and student but friends. This is very important. This is lovely."***

5.1.5 Further aspects

As in case of *ARTé: Mecenas*, the teachers from the *Variant: Limits* test group also mentioned one aspect of motivation which goes beyond the ARCS model.

Also with this game, it was mentioned that **collaboration** played a role in terms of motivation, although this aspect was limited to one remark:

> ***"Traditionally, they always work alone, and if they are to solve exercises with pen and paper, it is… I feel like it's less easy to get them to collaborate, or to get them to work together."***

5.1.6 The role of demotivation

It is a central difference between the games and maybe the most obvious divergence between the perceptions of *ARTé: Mecenas* and *Variant: Limits* that the teachers from the *Variant: Limits* test group made almost no remarks on demotivating factors and effects of their game. There was only one respective comment, and it was related to a technical problem rather than to the game as such:

> ***"Some of the students lost their saved games and had to start over. Starting over is not very motivating because it's kind of a once-in-a-lifetime game. You play it once. Some of the students who had played through the first two zones had to start over. For one, it was really boring for them to start over. It was very easy because they had already solved all the puzzles."***

Notably, this issue has been addressed by the game developers in the meantime who released a new version of the game in May 2018 which offers cloud saves.

Hence, it can be assumed that *Variant: Limits* was either motivating for the students or had a neutral influence, but it appears not to have had a negative influence on the motivation of students within the test group. The degree of motivation depended on a variety of factors, also including interpersonal differences. This aspect will be explored in chapter 5.3.

It will be subject to the following considerations to analyze in how far this high motivational potential manifests itself in the students' classroom engagement.

5.2. The impact of Variant: Limits on student classroom engagement

5.2.1 Behavioral engagement

The teachers in the *Variant: Limits* test group reported that their students demonstrated high behavioral engagement, referring to a number of aspects as explicated in the following.

First of all, the students showed **high effort** when playing:

> ***"They were so competitive at the game when they had to go up to the blackboard or just in the discussion of the classical lessons. Maybe they are very good because you see it from the tests, but they don't come out. In the game, they did."***

They were observed to also excel in **on-task attention and concentration**:

> ***"Concentration of students [worked really well]. Staying concentrated for one whole hour in spite of all peaks of attention. I would say I was also a bit afraid it seemed a bit addictive."***

Particularly many comments were made on the students' **high persistence, especially on difficult tasks**:

> ***"It made my students practice much more than what they do usually."***

5.2.2 Emotional engagement

With regards to emotional engagement, the teachers most centrally described that *Variant: Limits* evoked **frequent and strong positive emotions**:

> ***"Three hours in a row, it's tough to get their attention, so I booked the IT lab for the very last hour of every Saturday, and they were so happy. So happy to go to the IT lab and play and discuss."***

5.2.3 Cognitive engagement

In the *Variant: Limits* test group, there were numerous comments pointing out that students showed high cognitive engagement.

Mostly, these comments referred to **sophisticated learning strategies** that the students demonstrated:

> ***"[In other learning formats,] they do share ideas, but mostly it's, 'What did you get on that one?' 'Oh, I didn't get that.' So, they're mostly comparing answers, and not solutions, or not ideas. When we work with this [game], they share ideas more than they share answers, and that is something that I think is working well. […] Somehow I feel that sharing ideas is the main strength of this."***

5.2.4 Agentic engagement

The students were observed to demonstrate multi-faceted agentic engagement.

To start with, they **asked questions** on a number of occasions:

> ***"They have asked, several times, 'Are we going to play today? Are we going to play more? When are we going to play again?' So, you see that they want more and that they really like it."***

Furthermore, the students actively expressed **interests, preferences, and likes/dislikes**:

> ***"On Christmas day, [one student] called me and said, 'Sorry, teacher, please, I would like to continue. Help me, please'."***

The students also engaged in vivid discussions and in this context **offered suggestions**:

> ***"They were exploring, investigating and discovering in almost heated discussions, where they try to help each other and explain why this is working or why it's not working. To see that state of mind that they entered is really a cool experience."***

> ***"They discussed the concept of limits, without having any previous knowledge the concept."***

All in all, the consideration of the classroom engagement the students showed when playing *Variant: Limits* and engaging in game-based learning reveals that the potential of the game to evoke engagement can be considered high. Naturally, the effect on different students differed, but the overall impression is clearly positive.

5.3. Interpersonal differences in the impact of Variant: Limits™

The teachers in the *Variant: Limits* test group described some differences between students with regards to the effects that the game had.

5.3.1 Gender and culture

Most teachers did not discover or mention a significant difference between boys and girls with regards to their behavior or success with the game. One teacher described girls as peculiarly competitive and suggested a connection of gender and nationality or culture:

> ***"What I found out in the game was that many girls were very competitive, and usually, they are not, when they have to speak out in class. Did you notice this as well? In Italy, there is a difference of gender, probably more than in Norway or Germany. I noticed that the girls have a lot more grip on the things."***

5.3.2 General student performance

Regarding the general student performance, the teachers in this test group agreed that weaker students benefited more strongly (although they sometimes needed more time), while the impact on students who are generally good performers was perceived as less strong:

> ***"The game gives the benefits, especially, for the weaker students. […] Maybe this repetition […] helps the weaker students."***
>
> ***"The weaker students needed more time."***
>
> ***"What seems quite clear is that, actually, you are not impacting people who are already at a very high level that much."***

5.3.3 Gaming experience

Also in the test group of *Variant: Limits*, it was described that students with gaming experience had an advantage in handling and operating the game:

> ***"At first, I thought of having them explore the game, without have any explanations: they are playing, then we try to summarize what they have learned. I found out that it was not working because some of the students were completely lost probably also on the technical part. Only these are the students who never play games."***

5.3.4 Students with special needs

One teacher reported on his or her experience with students with special needs. In the context of varying preconditions between students, it is remarkable that these special needs did not or only marginally seem to make a difference:

> ***"We have students with special needs in the class, but it wasn't really an issue in any way. […] One of them had real difficulty with collaborating, and had to play alone, because… That's a student with Asperger's Syndrome, but normally, playing the game, or using the game for learning, wasn't an issue."***

It is remarkable that the teachers' comments on interpersonal differences regarding the effect of *Variant: Limits* and game-based learning are quite limited. It can be considered a success in terms of accessibility that students with special needs were reported to work with the game just like all other students. Also, the aspect of the game-based learning experience can be addressed by according learning activities or supportive measures on

behalf of the teachers, to help all students operate the game and learn how to work with it. The facet of gender is neglectable because a convincing majority of teachers indicated not to have discovered any differences here. Finally, the observation that weaker students benefit more strongly from the game deserves further attention. If teachers use *Variant: Limits* again in the future, they might take into account that the impact of the game on stronger students was perceived as lower in the study, and that they might want to take measures to ensure that stronger students can also take advantages of the game use.

5.4. Ways of implementing Variant: Limits

5.4.1 Implementation settings

With regards to the **location** of gaming, most of the teachers from the *Variant: Limits* test group chose a flipped classroom approach: the students mostly played at home, and the classroom hours were used for matters like trouble shooting, discussions and additional related work.

> ***"When you're in a flipped classroom, you can make an instructional video that every student looks at, individually, when they are alone. When they come to the classroom, where you, as a teacher and their co-students are, they should interact with each other. As far as I can see, that's the point of the flipped classroom. You take advantage of the fact that there are more people together, and you do things are good to do when you are alone. Playing individually is a good thing to do at home, and playing together and discussing the solutions to the problems and puzzles is a good thing to do in the classroom."***

The reasons for the prevalence of flipped classroom approaches can be understood as twofold: on the one hand, the teachers appreciated the possibilities of this approach and the potential for learning, as the excerpts above show, and on the other hand, limited time was a facilitator for flipping the classroom, or having the students play at school and at home as a combination:

> ***"Then the students were playing some of the puzzles in school and mostly at home because, actually, there is not enough time otherwise."***

Only a small minority of teachers disapproved of this approach and decided to have the students play in the classroom only:

> ***"My students use the game only at school. I'm not convinced to giving them a lot of homework at all."***

In terms of **social settings**, the teachers reported using a variety of approaches, although it is a consequence of the high number of flipped classrooms that a lot of gameplay was done at home, i.e., individually. In accordance with that, some scenarios also involved individual gaming at school:

> ***Teacher:*** *"When we think about an individual approach to teaching, that's a great idea, because they can learn at their own pace. That's a really good aspect of the game."*
> ***Moderator:*** *"So, you would not have the students pair up and play together, but individually?"*
> ***Teacher:*** *"Yeah. Yeah, because they've got to solve the problems in their head individually. They can discuss. There is no problem talking to each other, or they can even stand up and go to their best friend or whatever, but finally, my idea is that they finish the game by themselves, with help from their colleagues."*

Some teachers preferred to have their students work in pairs:

> ***"They sit in pairs, and play in pairs and help each other. […] I think it's worked out, because they help each other, and they talk, and it's good. I think it's good."***

A third approach that was mentioned favors work in small groups:

> ***"They play but in small groups."***

5.4.2 Teaching and learning activities

The teachers working with *Variant: Limits* who talked about their methods of **introducing the game** all favored teachers' explanations about how to play the game:

> ***"When I implemented the game, I did it in the classroom. I guided them through the steps to register, download and start playing. Then I let them explore the game individually, at first."***

Regarding the **purpose** of the game use, one part of the teachers used it as a repetition, and to practice material already learned:

> ***"We use them in a mathematics class that had already been through the topic of limits, and they had already been through traditional exercises, and even traditional assessment of the topic. Then we did this as a recap, and to provide a different view on limits, and more of a geometrical approach. Many of the students already knew what was going on. It was more contextualizing geometrical interrelations, not so much an introduction or teaching new concepts."***

The second group of teachers used *Variant: Limits* mainly as a tool for knowledge acquisition and in order to provide information and new contents:

> ***"They hadn't encountered limits as a concept in their math education yet."***

The teachers described various **teaching and learning activities** which they used in connection with the game.

Some of these activities served to repeat contents from the game:

> ***"When they go back to the traditional classroom, I make some questions with graphics with limits, and they solve them very well."***

Other activities were used to enhance, deepen and/or amend contents from the game:

> ***"I think most of them don't follow the plot, so we talked about making a transcript from the game, and using it in the English classes."***

The teachers also created assessment activities in the context of *Variant: Limits*:

> ***"It's for this purpose that I created all the assessments […]. I made a screenshot of a particular puzzle which gathered mathematical parts, which I wanted to dig into deeper during the lesson. Then I gave them the puzzles outside of the game. So, they were playing with the puzzle, but not inside the game. Exactly for the purpose. I like doing that."***

One teacher also described an activity which allowed for a reflection on game-based learning as a teaching and learning method:

> ***Teacher:*** *"The advantage was that they practiced more, and they were more willing to practice.*
> ***Moderator:*** *"Did you reflect about that with the students?"*
> ***Teacher:*** *"Yes. They said they agreed."*

Finally, there was one teacher who preferred playing without additional activities:

> ***Moderator:*** *"Did you provide them with any additional instructional material, or are they mainly focused on playing?"*
> ***Teacher:*** *"Just playing. In these classes, it's just playing."*

5.4.3 Barriers, problems and difficulties

The facets mentioned so far hint at a prevailing success of the game implementation in the ***Variant: Limits*** test classes. Yet, the teachers also described a number of barriers, problems and difficulties that they faced.

Lesson integration

Several teachers talked about problems related with **insufficient time**, as they would like to have more time to use the game in their classes:

> ***"I would like to have free time, not under the pressure of the program, to do this in my school program because now we are running to finish the curriculum that the ministry gives us."***

In this context, it came up in different statements that implementing the game took too much time, especially in comparison to traditional ways of teaching. Yet, the teachers also considered the fact that they were using *Variant: Limits* for the first time, and that future implementations might work faster and with less effort and time:

> ***"When I compare it with the usual amount of time I use to deal with this part of the topic, using the game stretches the time. I needed more time. I had higher grades, and all of my students were successful in the final summative assessment, but it took more time."***

> ***"Probably because I am piloting it, I'm even taking too much time."***

With regards to the **curriculum fit**, there were different perceptions. Some teachers appreciated the contents as a perfect fit:

> ***"For me, the best thing about this implementation is that I prepare my students for university exams. The level of knowledge in the game are referred in our curriculum for university exams. So, our students refer me: they feel ready to solve exercises on this level. This is very important because, in our curriculum, students get extra licenses and pay for extra licenses to prepare. They have knowledge of the university. Now, they prepare their knowledge through games. This is very important."***

Other teachers however criticize the contents of the game – in parts or as a total – as not relevant for their curriculum:

> ***Teacher A:*** *"Do you have this intermediate value theorem in your curriculum? I had problems with part three."*
> ***Teacher B:*** *"Yes. Yes."*
> ***Teacher C:*** *"IVT."*
> ***Teacher B:*** *"IVT. Intermediate Value Theorem. That's the [inaudible] theory. Yes."*
> ***Teacher D:*** *"We don't either."*
> ***Teacher C:*** *"It's a college curriculum for us."*

> ***"In our school there is only one class with a curriculum where limits are. In every class, there's no limits at all, and in the classes I teach, there is no limit concept in the curriculum."***

Language

Some teachers described the **English language** as a problem:

> ***Teacher A:*** *"The students from this class, there is no problem with general English, but the vocabulary in the game, it's not an easy one. And when they speak really fast… […]"*
> ***Teacher B:*** *"You can have subtitles."*
> ***Teacher A:*** *"Yeah. Even with subtitles, it's a problem for some of them, because you've got to come back and listen again."*

However, some teachers also turned this issue into an opportunity to learn and established a collaborative CLIL-approach with English teachers:

> ***"For my students, language was a problem. I tried to do as much collaborative work with my colleague teachers as possible, so that was a good opportunity, because I've never done one project with the English teachers."***

Technology

For many teachers, the **technical equipment available** was challenging. 'Bring Your Own Device'-Approaches were not possible in every case due to the students' equipment status:

> ***"The problem with the game is that […] I'm not in a situation like [the Norwegian teacher] is, because my students… I don't think everyone has his own laptop […] to bring to school."***

As a consequence, most teachers had to use the school IT labs, which was also described as problematic in several cases due to the limited availability of such rooms:

> ***"The problem is the lack of computers in my classroom. That's the problem. They've got to change rooms to play, so my plan didn't fit their plan. That's the problem."***

Technical issues also occurred **within the game**.

Registering and creating accounts was perceived as problematic:

> ***"Creating accounts, and how to do it [was difficult]. It's difficult for some of them, because there was some kind of misunderstanding of where to put the email address, their username…"***

There were also cases in which things did not work as expected, e.g. with regards to the download, the online functions, and lost save game files:

> ***"It's a bit tricky at the moment in this version too because we have to take out the file to bring it home, or the system will not recognize the point where you have arrived. Being online is important to see how much the student has done, but it was not recording this kind of thing. […] Some students were not able to find the file so they had to restart."***

> ***"Some of the students lost their saved games and had to start over. Starting over is not very motivating because it's kind of a once-in-a-lifetime game. You play it once. Some of the students who had played through the first two zones had to start over. For one, it was really boring for them to start over. It was very easy because they had already solved all the puzzles."***

As pointed out above, these technical problems have been addressed in the meantime by releasing a version that offers cloud saves.

Students

In a small number of cases reported, there were students who did not accept the game-based learning-approach and **refused to play**:

> *"Especially, one [student] completely refused to play the game. 'I want to do some exercises.' 'Uh, okay. That's okay. You can sit here in your seat and do exercises. That's fine. You don't have to play the game.' I had two more students realizing that, 'While this is fun, and the narrative is fun, I will probably get more practice from doing exercises,' so they stopped halfway through, because they were more focused on actually understanding mathematics, because they think that part is fun."*

Further students showed **problematic behavior**, mostly because they used a "trial and error" approach and just tried to click through the game without thinking about the mathematics behind it:

> ***"At the beginning, because they had no experience with what limits are, there was a lot of guessing, and the game, for them, was just trial and error at the beginning. We've got to put a lot of focus on not just trying every possible input to have access to the next level of the game."***

Game mechanics

Most criticism regarding the game mechanics focused on the fact that the puzzles were perceived as quite repetitive, and that an increase in difficulty just applied to gaming elements, but not to the mathematical part of the game. This perception of the game being too easy at points is critical because it violates the principle of good computer game design stating that games should always be balanced in their difficulty, i.e. challenging but fair and neither too hard nor too easy at any point (Prensky, 2001, p. 133).

> ***"I think students, to be prompted to study, they have to feel cool — have to be very good things. Yes. It has to be rewarding for them, personally, and if you keep asking the same questions, it stops being rewarding. I mean, it's always the same. So, 'Do you think I'm stupid? You are asking almost the same question to me.' It's not rewarding."***

More specifically, the repetitive character was considered problematic also because it means a drill-and-practice approach:

> ***Teacher A:*** *"I found the puzzles a bit too repetitive. My students noticed that. I mean, in the last part, the zone four part, the game gets tough, but the game gets tough, not the puzzles. The puzzles are always on the same thing. It's a drill approach, which is peculiar to the American way of learning something. […]The drill approach… To me, it's extenuating. I need something that gets tougher or different. Don't use the same thing and the same thing and the same thing. […]" […]*
> ***Teacher B:*** *"Yes. […] A lot of the increasing difficulty is in the puzzles[…]. It's in the game mechanics, and in the game, and not really in the mathematics part of it. Especially my students who are senior students, and most of them are turning 19 about now, they quickly realized that the game doesn't get difficult fast enough. It starts off quite okay, but the pace is too linear, and too slow for them."*

It is interesting in this context that a considerable amount of literature supports the teachers' criticism here. While drill-and-practice approaches do have their worth and can support the acquisition of knowledge, e.g. in automatizing basic skills (cf. Lehtinen, Hannula-Sormunen, McMullen, & Gruber, 2017), studies have revealed a number of disadvantages. For example, students were found to consider mathematical software designed following a drill-and-practice approach as not motivating and would prefer to work with text books (Kuiper & de Pater-Sneep, 2014), and other learning formats such as deliberate practice have been described as superior to drill-and-practice approaches for practicing processes within mathematical education (Lehtinen, Hannula-Sormunen, McMullen, & Gruber, 2017). More variation in the game mechanics and in tasks and puzzles might address the criticism of the drill-and-practice-approach. However, this would mean changing a central part of the game, and it should be considered if the benefit of such an elementary change is worth the effort, or if there are ways to amend the game contents in a way that meets the criticism without changing the whole idea of the game.

Further criticism regarding the game mechanics addressed the lack of familiar game elements, in this case enemies:

> ***"They just started asking if we're enemies in the very beginning. [chuckling] […] They want enemies."***

Missing contents

There was a certain consensus that the **contents** of the game were problematic because they neglected certain aspects. The teachers perceived this as an issue because using the game was not enough for the subject topic, but they had to enhance and go on with the topic in the aftermath. An additional quotation regarding missing contents can be found in appendix 10.2.

> ***"In our curriculum, the reading limits from the graph, and connecting limits to the graph, is not enough. I have to teach them to evaluate limits. […] This part is not included in the game, so my activities with the game are finished, but I have not finished with limits at all with the class."***

> ***Teacher A:*** *"What I've noticed is, there's no formulas at all."*
> ***Teacher B:*** *"No. No."*
> ***Teacher A:*** *"Don't you think it's […] a missing part?"*
> ***Teacher B:*** *"A missing part. Yeah. Of course. Yes."*

Pricing

In the *Variant: Limits* focus group discussions, the teachers vividly discussed the pricing and models of payment when talking about barriers for using the game. They reached a consensus that it is not a realistic concept for students to buy a license on their own. Depending on the respective country background, the teachers saw problems also with the ideas of schools purchasing the licenses, and with the level of costs:

> ***Teacher A:*** *"I also wonder, as we are looking into the future, about the price. I'm not doing marketing. So, I don't think that any students would pay $25 euros to play a math game. The idea is that the schools have licenses. In Italy, we are always […] struggling with money."*
> ***Teacher B:*** *"In Greece, no one will pay to play games. […] It's not something for the ministry of education. The materials of the ministry of education in Greece are free. I don't think that schools will pay. Also, maybe, in this case, parents will have problems with this. The education in a public school is free. We don't pay for books. We don't pay for anything."*

The problems and difficulties described in this chapter refer to different levels. One group of problems could be addressed by the game developer, such as translations, technical issues within the game, changes in the game mechanics, the contents of the game, and pricing issues. Other problems are to be tackled by teachers working with the game, i.e., student behavior or the organization of media labs or technological equipment. However, the problems described about the curriculum fit of the game may be difficult to solve, because it has been discovered that the mathematics curricula vary strongly between European countries. Presumably, this will mean that certain schools or countries will be less interested in purchasing *Variant: Limits* licenses because it might not fit their curricular needs.

5.5. Teachers' suggestions for improvement

In the focus group discussions, the teachers expressed different suggestions for improvement of *Variant: Limits™*. These suggestions referred either to technical aspects or to the game content. Further ideas for improvement can be derived from chapter 5.4.3.

5.5.1 Improvement with regards to technological aspects

The comments in this category relate to **cloud accounts** or **transferable accounts**, which have been included in the meantime:

> ***"We have bought, like, 30 copies of Civilization, and 30 copies of… Yeah. Many games, actually. The last was 30 copies of 'Keep Talking' and 'Nobody Explodes.' Those are installed on the school's Steam accounts, so if it's linked to a school Steam account, then we can just log in with that account on a computer, and download the game, and then delete it and move it to a different computer with the same Steam account. That would probably be something to do. Then we could buy 30 copies and use it again, and use it again, and use it again, no problem."***

5.5.2 Improvement with regards to contents

First of all, the **addition of content** related to the evaluation of limits, infinity and indeterminate forms, and formulas was suggested (cf. chapter 5.4.3, "missing contents").

Several teachers also expressed their requirement to **change, amend and add puzzles**:

> ***"What I suggested […] is to implement a possible design mode, where the teacher can design puzzles that are not part of the main narrative."***

> ***Teacher A:*** *"So, you can make sure that all your students have done the kind of puzzle that you want them to do, and you can design puzzles for assessment that are a little different from what they have been doing."*
> ***Teacher B:*** *"Or you can ask them to design the puzzles."*
> ***Teacher A:*** *"Yes, you can do that too, if you know the puzzle designer."*

Also, it was perceived as a potential improvement to have more **flexibility** within the game and the order of the puzzles. Some teachers would appreciate it if students were able to access selected puzzles directly:

> ***"As a teacher, I would like the possibility to assign specific puzzles to the students. Right now, I want us to take a look at this puzzle. Then we can discuss it. To do that, all the students have to get to that puzzle. The puzzles that are interesting to work with on that level are really far out into the game. So, when you need all the students to get to that point in the game, I would like an option to give that puzzle to the students who haven't gotten that far."***

However, some teachers disapproved of the idea of flexibility, considering the impact this would have on the narrative:

> ***"I kind of agree with [another teacher] that from a mathematics point of view, it would be nice to be able to skip all students to what this class is about, but you lose so much of the game when you lose the narrative, and it's not really a good idea in this game, although it would be practical for the teacher."***

Moreover, some teachers showed interest in **working with the graph templates and software** even beyond *Variant: Limits*:

> ***"I would like to have the possibility to use the — it's just an idea — the graph template of the game outside of the game. So, I was just thinking that now, if you have to evaluate an indeterminate form, you can just plug in the function and see the graph, but if the graph is similar to the graphs I've seen in the game, that would be more engaging for them, I think, with the black and green parts. It's just a stupid thing, but just to link the two pieces together, to make them feel, like, Equa again outside of the game."***

It can be interpreted that the priorities of these content-related suggestions differ. The teachers showed a consensus in relation to the requirement to change, amend and add puzzles. Also, there were several teachers asking for the graph templates and software. It might be worth considering to give teachers more flexibility in this regard, and to provide them with an easy-to-use puzzle designer mode.

Regarding the request for additional material, this aspect might deserve further inquiry, because it has been discovered that the curricular requirements vary between countries, and so does the need for specific content. Finally, flexibility within the puzzles and the option to select certain puzzles and content directly was discussed quite controversially, and it is not possible to decide whether this would be a beneficial addition or not, based on the focus group results. Further inquiries would be necessary in this context, too. It might be a viable solution to include an option for teachers to assign specific puzzles to their students for limited timeframes to allow for a focused discussion of mathematical problems.

5.6. The impact of Variant: Limits™ on student content knowledge acquisition

In case of *Variant: Limits*, teachers made a number of comments regarding their students' knowledge acquisition.

In this context, there were numerous **general or unspecific remarks** like the following:

> ***"The results are really very impressive because they get knowledge."***

> ***"[The game] prepares their knowledge for university exams. They upgrade the mathematical level."***

Other comments refer to the **mathematical contents** that the students acquired, and they mostly refer to the concept of limits or functions. In this context, it was a central observation that the game helped **contextualization**:

> ***"For a few students that I talked to, it also helped them to be more conscious about the domain of the functions they were working with, and not just the functions themselves. That, I think, is a big plus, because the domain of a function is crucial, but most students, especially high school students, don't see it that way."***

The students also acquired further skills beyond the content knowledge, such as **formal mathematical language** and **meta skills**:

> ***"I think it helped my students' self-awareness, as I said, in a meta-cognitive way."***

> ***Teacher A:*** *"The good thing about having students working together and trying to explain is that, for instance, we have some students who are very good at math. They are very good at limits, when they learned what it is, but they are not able to explain in words. They are not strong in*

language. If they have to explain it to others and not say, 'Click there,' they are forced to come out with this aspect, which is important."

Teacher B: *"It also adds a level of understanding when they have to rephrase it."*
Teacher A: *"Then they may say that they're not able to be understood by the others. So, they have to refine it. This is a great thing."*

As a conclusion, the teachers perceived that their students gathered knowledge in different facets, including the target mathematical knowledge about limits and functions as well as meta skills and mathematical language.

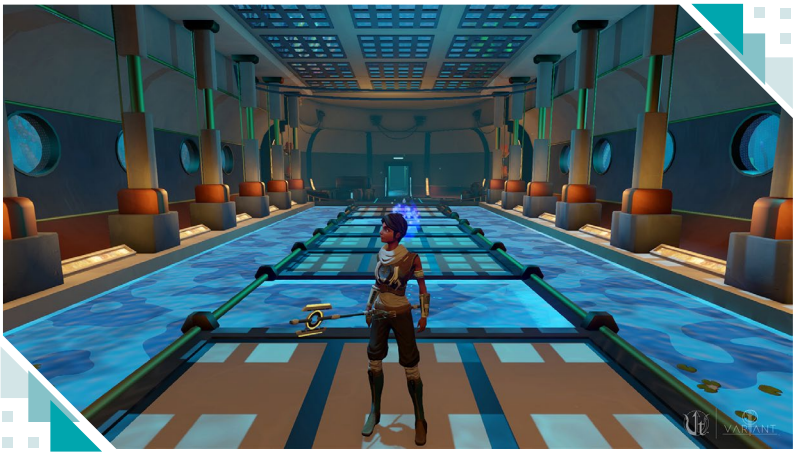
6. CONCLUSIONS

Motivation

Overall, both the questionnaire data and the focus group discussions revealed a strong motivational potential of *ARTé: Mecenas™* and *Variant: Limits™*. The questionnaire data indicated slightly higher values for the motivational potential of *Variant: Limits*, and the focus group analysis of this game was confirmative in this respect. In case of *ARTé: Mecenas*, the results are not as one-dimensional because while teachers confirmed that *ARTé: Mecenas* had a positive influence on the motivation of most students, there were circumstances and conditions under which the game had a demotivating effect. The direction that the motivational or demotivational potential may take is dependent on a multitude of factors. Some of these may be influenced, e.g., the teaching scenarios and settings in which the game is integrated, and other factors cannot be influenced or only indirectly by the selection of classes, e.g., general student performance. Yet, the teachers' overall impression of the motivational potential of both games can be summarized as positive.

Classroom engagement

It is consistent with this positive perception of the motivational potential that the teachers also confirmed a mostly high classroom engagement with the students in the project classes, both in the surveys and in the focus group discussions and with a slightly more positive tendency for *Variant: Limits* expressed in the surveys. While again, this observation cannot be applied to each student – which can generally never be expected due to heterogeneous groups –, most students showed behavioral, emotional, cognitive and agentic engagement.



Ways of implementation

The analyses of ways of implementation showed that the teachers faced different preconditions, e.g., in terms of heterogenous student groups or technical equipment of limited availability, and came up with creative and unique solutions to meet their specific situations. They encountered a number of problems and usually found ways to overcome these. The teachers also described their unique implementation scenarios, which show certain trends: e.g., most teachers preferred to have their students play both at home and at school or in flipped classroom settings, they all designed a variety of teaching and learning activities to accompany the game use, and they experimented with social settings and had their students play in all kinds of combinations, ranging from individual play to teams, groups or even with the whole class.

Knowledge acquisition

The overall impact on knowledge acquisition was perceived as positive with both games, as surveys and focus groups revealed. Students learned things within the scope of learning goals that was predefined by Triseum, and also beyond. In this context, it was central for a number of teachers to point out that *ARTé: Mecenas* helped their students acquire a broader image of the Renaissance times and contextualize their knowledge of contents and relationships, which was mostly understood as more important than learning about single artists or pictures. Likewise, the teachers from the *Variant: Limits* test group explained that the contextualization of limits was a central advantage of the game.

All in all, both the analyses of the questionnaires and of the focus group discussions revealed that the fostering of motivation, classroom engagement and knowledge gain can be classified as successful, and this classification matches the evaluation of the teachers, who mostly rated the project as “rather successful” or “very successful” in the contexts of both surveys and focus groups.

It should be noted that there are certain caveats for the positive outcomes that were attributed to both ***ARTé: Mecenas*** and ***Variant: Limits*** in this evaluation. Most centrally, focus groups are a qualitative means intended to gather feedback and to get insight into the participants’ thoughts and experiences. This means that the results are subjective, and their transferability is necessarily limited. Against this background, the combination of focus group analysis and pre- and posttest results has proven successful and strengthened the informative value of interpretations. Yet, further methods could amend these findings, e.g., by measurements that take into account the students’ perspective.

There is great consistency of questionnaire results and focus group discussions: for example, the three problems which were mentioned most often in the surveys are insufficient time, technical problems and language, and these three issues were mentioned and discussed in the face to face-sessions as well and elaborated on in more detail. Insofar, the questionnaire data serve to provide an overview of implementation modes and game impact, while the focus group discussions amend these data and contextualize and explain the figures. Thus, the overall high consistency of pretest and posttest questionnaire analyses and focus group results supports the triangular research approach, and data from both sources amend each other. There are few cases in which the results diverge; e.g., some teachers did not mention teaching and learning activities in the focus group discussion but described respective activities in the posttest survey. Such divergences can be explained to stem from limited English language skills, which made it more challenging for some teachers to express their experiences in free conversation and restricted some contributions. Against this special background, it has proven even more useful to select a mixed methods approach because the results show that every teacher had a chance to share his or her experiences in some way or another.

7. RECOMMENDATIONS

The following recommendations summarize and build on the evaluation results of the Triseum validation study as presented above and introduce conclusions on a meta perspective. They offer ideas that may trigger further considerations and stimuli for a number of actions which are intended to enhance, support and improve future implementations of *ARTé: Mecenas™* and *Variant: Limits™* in international contexts. It should be noted that the perspective of these considerations is a pedagogical one. Some recommendations may be considered useful but not practical in terms of resources etc. It is beyond the scope of this report to judge about cost-benefit calculations, and it might make sense to seek further investigations and take into account more aspects for grounded decisions on the possible realization of the following ideas.

Recommendation 1: Consider and further investigate cross-national differences

Concerning the **cross-national applicability** of *ARTé: Mecenas* and *Variant: Limits*, the pilot project has revealed an overall applicability for Norway, Greece, Poland, Portugal, and Italy, in so far as the objectives of stimulating motivation, classroom engagement, and content knowledge are considered. Yet, there are differences in the perceptions of facets as for example the range of content of *ARTé: Mecenas*, which has been described as less relevant for the curriculum in Norway, but as too restricted for the curriculum of Italy which covers more than the game contents in the context of Renaissance. Also, in the context of different experiences between countries, teachers assessed the fact that both games are in English language differently, and some teachers had problems with the English language and would like to see **translated versions**. However, this is a controversial idea, because other teachers also considered the foreign language an advantage and developed interdisciplinary learning scenarios which combined e.g. arts and language or mathematics and language. It could be a solution to offer a limited number of translated versions for the countries which expressed their interest, as for example Portugal and Italy. It could also be viable to include country-specific dictionaries with important keywords, or to do without translations and provide teachers who want to work with the games with CLIL-oriented approaches and ideas to support their individual learning scenarios.

Against the background of such varying experiences of different countries, it might be advisable to seek further investigations or studies which involve more European countries and employ a variety of further methods to amend the research results.

Recommendation 2: Consider and enhance teachers' preparation and support

The evaluation results showed that a careful **technical and pedagogical preparation and ongoing support** for teachers who intend to implement *ARTé: Mecenas* and *Variant: Limits* is vital for the success of the game-based learning teaching unit. It is strongly recommendable to offer supportive measures such as e.g., videos, presentations, downloadable contents and live support. Another central idea in this context is establishing networks between teachers interested and taking advantage of their experiences and communicativeness. Teachers should be considered stakeholders in the promotion and support of *ARTé: Mecenas* and *Variant: Limits* and be supported in their game-related exchange, e.g. by forums, chats, Twitter chats and other forms of personal learning networks. This is true not only for the context of *ARTé: Mecenas* and *Variant: Limits*, but also for game-based learning in general. The teachers in the validation study took advantage of their preparation and support throughout the project via various activities offered and organized by Triseum and European Schoolnet, such as face to face meetings in the EUN future classroom lab and several webinars, and it is likely that according measures can complement and enhance game-based learning scenarios also in other contexts.

Recommendation 3: Review, amend and add didactic and pedagogical materials

The selection of **didactic and pedagogical materials** which are recommended to accompany the games will have a sound basis if they include and build on the game-based learning pilot project evaluation results. E.g., the evaluation report revealed the strength of a teaching approach that combines playing

at home and at school lessons, as in a flipped classroom approach, because it has proven successful and efficient to accompany the students when playing actively, while giving them room to play freely and minimizing the classroom time needed, which is a requirement many teachers expressed. Also, the pilot project showed that learners' groups are heterogenous and that their characteristics have to be considered carefully to foster motivation, classroom engagement and content knowledge acquisition effectively, and to ensure a successful game implementation. Hence, future game-based learning teachers should be provided with respective scenarios, materials and stimuli to build on these experiences and enrichen them with own approaches.

Recommendation 4: Strengthen and further research game-based learning

Overall, the validation study revealed a strong potential of game-based learning as an approach to teaching and learning in terms of students' motivation, classroom engagement, and knowledge acquisition. The results suggest that game-based learning has proven successful, which leads to the conclusion that this approach should be proceeded with and strengthened in further research and practice, especially in view of a limited transferability due to methodological reasons and the exemplary selection of two games. For the research perspective, this might include e.g. research on further games and more effects beyond these that were focused in the validation study, using various methodologies and including diverse target groups. In terms of practical applications, the results offer a confirmation for developing, using and evaluating game-based learning approaches in educational settings.

The careful consideration and realization of these recommendations is hoped to contribute to the positive development that game-based learning as well as both ***ARTé: Mecenas*** and ***Variant: Limits*** show. Both games and game-based learning have proven to be powerful tools for fostering motivation, classroom engagement and content knowledge acquisition of students in Norway, Poland, Greece, Portugal, and Italy and can be expected to unfold their potential and facilitate learning processes of many more students to come.

8. ACKNOWLEDGMENTS

We would like to thank the the European Schoolnet Ministry of Education representatives in Greece, Italy, Poland, Portugal and Norway, as well as the Team of the ICT Competence Center of the University of Minho for their support in the implementation of the project.

The Triseum Validation Pilot would not have been possible without the valuable contributions from the Triseum Pilot teachers, who were always at the core of the activities carried out in the project. From providing input for the present evaluation report to developing Future Classroom Scenarios for the implementation of the two Triseum games and providing feedback on the various project activities, their support and flexibility was vital to the success of the project.

Triseum Pilot teachers

- Panagiota Argyri, Model High School Evangeliki of Smyrna, Greece
- Giulia Giovanna Bini, Liceo Scientifico Leonardo da Vinci , Italy
- Maria Manuela da Silva Durão, Escola Secundária de Rio Tinto (Porto), Portugal
- Spyros Douvlis, UpperSecondary School of Karditsa, Greece (although no longer with us, Spyros continues to inspire with his curiosity, openness and dedication)
- Alberto Garniga, Liceo Antonio Rosmini di Rovereto, Italy
- Michał Głatki, Zespół Szkół nr 1 w Tychach, Poland
- Håvard Hatlevik, Nordahl Grieg upper secondary school, Norway
- Gaute Hauge, Nordahl Grieg upper secondary school, Norway
- Evangelia Karimali, Model High School Evangeliki of Smyrna, Greece
- Annamaria Lisotti, Il S Cavazzi, Italy
- Geir Myhr, Nordahl Grieg upper secondary school, Norway
- Francesca Pellegrino, I.S. Giovanni XXIII Cosentino, Italy
- Alberto Augusto Piçarra Figueiredo, Escola Secundária de Rio Tinto (Porto), Portugal
- Agnieszka Pielorz, IV Liceum Ogólnokształcące im. Mikołaja Kopernika w Rybniku, Poland
- Despoina Poimenidou, 1st Experimental Lyceum of Thessaloniki “Andronikos”, Greece
- Vegard Relling, Nordahl Grieg upper secondary school, Norway
- Paula Santos, Escola Secundária Sá de Miranda (Braga), Portugal
- Anita Streich, Zespół Szkół Gastronomiczno-Hotelarskich/ Technical School of Hotel Managment and Catering Industry, Poland
- Anna Sulek, Zespol Szkol Elektronicznych i Licealnych, Poland
- Carminda Maria Teixeira Meireles, Escola Secundária de Fafe, Portugal

9. LITERATURE / MAIN SOURCES

Csikszentmihalyi, M. (1990). ***Flow: the Psychology of Optimal Experience***. New York: Harper Perennial.

Elliot, A.J., McGregor, H.A., & Gable, S. (1999). Achievement goals, study strategies, and exam performance. A mediation analysis. ***Journal of Educational Psychology, 91***, 549-563.

Huang, W.-H., Huang, W.-Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. ***Computers & Education, 55***, 789-797.

Keller, J.M. (1987). Development and Use of the ARCS Model of Instructional Design. ***Journal of Instructional Development, 10***(3), 1-10.

Krueger, R.A., & Casey, M.A. (2015). ***Focus groups. A practical guide for applied research***. 5th ed. Los Angeles, London, New Delhi, Singapore, Washington D.C.: Sage.

Kuiper, E., & de Pater-Sneep, M. (2014). Student perceptions of drill-and-practice mathematics software in primary education. ***Math Ed Res J, 26***(2), 215-236.

Lee, W., & Reeve, J. (2012). Teachers' estimates of their students' motivation and engagement: being in synch with students. ***Educational Psychology: An International Journal of Experimental Educational Psychology, 32***(6), 727-747.

Lehtinen, E., Hannula-Sormunen, M., McMullen, J., & Gruber, H. (2017). Cultivating mathematical skills: from drill-and-practice to deliberate practice. ***ZDM Mathematics Education, 49***(4), 625-636.

Litosseliti, L. (2003). ***Using focus groups in research***. London, New York: continuum.

Mayring, P. (2015). ***Qualitative Inhaltsanalyse. Grundlagen und Techniken***. 12th ed. Weinheim & Basel: Beltz.

National Council for the Social Studies [NCSS] (2010). ***National curriculum standards for social studies: A framework for teaching, learning and assessment***. Silver Springs, MD: NCSS.

Prensky, M. (2001). ***Digital Game-Based Learning.*** St. Paul: Paragon House.

Reeve, J., & Tseng, C. (2011). Agency as a fourth aspect of students' engagement during learning activities. ***Contemporary Educational Psychology, 36***, 257 – 267.

Reynolds, K.M., Roberts, L.M., & Hauck, J. (2017). Exploring motivation: integrating the ARCS model with instruction. ***Reference Services Review, 45***(2), 149-165.

Skinner, E.A., Kindermann, T.A., & Furrer, C.J. (2009). A motivational perspective on engagement and disaffection: Conceptualization and assessment of children' s behavioral and emotional participation in academic activities in the classroom. ***Educational and Psychological Measurement, 69***, 493-525.

Takeuchi, L. M., & Vaala, S. (2014). Level up learning: A national survey on teaching with digital games. New York: The Joan Ganz Cooney Center at Sesame Workshop.

Wolters, C.A. (2004). Advancing achievement goal theory: Using goal structures and goal orientations to predict students' motivation, cognition, and achievement. ***Journal of Educational Psychology, 96***, 236-250.

Wu, M. L. (2015). ***Teachers' experience, attitudes, self-efficacy and perceived barriers to the use of digital game-based learning: a survey study through the lens of a typology of educational digital games***. Dissertation. Michigan State University.

10. APPENDIX

10.1 Pretest and Posttest Questionnaires

The development and composition of the survey items from pretest and posttest questionnaires was based on research on existing measurement instruments. Some items that had proven successful in other surveys were reused here, partly in their original version and partly after being carefully adopted to optimally fit the Triseum pilot context. This particularly applies to the items about "Teacher Experience with Digital Games" (cf. chapter 3.1), which are mainly based on Takeuchi (2014), and to the items from chapter 3.2, "Teacher Perceived Self-efficacy and Beliefs", which show references to Wu (2015). The operationalization of motivation used throughout the study is based on Keller (1987) and was measured by items as suggested by Huang et al. (2010; cf. chapters 3.6.1, 4.1 and 5.1). Classroom engagement was understood and measured according to Lee and Reeve (2012; cf. chapters 3.6.2, 4.2 and 5.2). The literature-based items were amended by further qualitative and project-specific items which had to be developed individually.

Pretest Questionnaire

0. Self-generated identification code

The following 6-digit code will allow us to match your answers from the first and the second survey and will keep your data anonymous at the same time. No identification will be possible.

Please generate your code from following three questions:

What day of the month is your birthday? (Two characters)

First two letters of your mother's first name.

Your father's birth year (two characters)

→ _____

(Example: if your birthday was May 8th, 1975, and your mother's first name was Julia, and your father was born in 1950, then your code would be 08ju50.)

1. Personal information

Please provide the following personal information:

1.1 Age _____

1.2 Sex female ☐ male ☐ other ☐

1.3 Which country are you from?

- ☐ Greece
- ☐ Portugal
- ☐ Poland
- ☐ Italy
- ☐ Norway

1.4 How did you get to participate in this pilot? *(Select all that apply)*

- ☐ I was selected by the Ministry of education in my country
- ☐ I responded to an open call from European Schoolnet
- ☐ I responded to an open call published at national level
- ☐ Other, please indicate: _____

2. Teacher experience

The version of item 2.1 depends on the choice of countries made in 1.3.

2.1 $_{\text{Norway}}$ What kind of school do you teach at?

- ☐ Secondary school I (Ungdomsskole)
- ☐ Secondary school II (Videregående skole)
- ☐ Other, please indicate: _____

2.1 $_{\text{Greece}}$ What kind of school do you teach at?

- ☐ Secondary school I (Γυμνάσιο)
- ☐ Secondary school II (Επαγγελματικό Λύκειο)
- ☐ Secondary school II (Επαγγελματική Σχολή)
- ☐ Other, please indicate: _____

2.1 $_{\text{Portugal}}$ What kind of school do you teach at?

- ☐ Secondary school (Ensino Secundário)
- ☐ Other, please indicate: _____

2.1 $_{\text{Poland}}$ What kind of school do you teach at?

- ☐ Secondary school I (Gimnazjum)
- ☐ Secondary school II (Szkoła zawodowa)
- ☐ Secondary school II (Liceum ogólnokształcące)
- ☐ Secondary school II (Technikum)
- ☐ Secondary school II (Liceum profilowane)
- ☐ Other, please indicate: _____

2.1 $_{\text{Italy}}$ What kind of school do you teach at?

- ☐ Secondary school I (Scuola Secondaria di Primo Grado)
- ☐ Secondary school II (Istituto Professionale)
- ☐ Secondary school II (Liceo)
- ☐ Secondary school II (Istituto Tecnico)
- ☐ Other, please indicate: _____

2.2 How long have you been a teacher?

- ☐ Pre-service teacher/ initial teacher training
- ☐ < 5 years
- ☐ 5-15 years
- ☐ > 15 years

2.3 Please list all subjects you usually teach. _____

3. Classes

1.4 How many classes are you going to involve into this project?

(Please note: your selection is not binding, you can still change your mind.)

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

1.5 Please characterize your project class: ***(to be filled in for each class, fields provided according to the number of classes as indicated in 3.1)***

- How old are the students in your project class? _____
- Which grade is this class in? _____
- How many students are there in this class? _____
- Please characterize your learners in this class briefly (e.g., attention/focus issues, gifted and talented, ect.). _____
- Which game will you implement in this class: ARTé: Mecenas or Variant: Limits? _____
- In which subject will you implement the game with this class? _____

4. Experiences with Game-based Learning

4.1 Do you ever play video/digital games (i.e., computer or video games, smart phone game apps, and/or social media games) for entertainment or other non-work/ non-professional related reasons?

- ☐ Daily
- ☐ 2-4 Days per week
- ☐ Once per week
- ☐ 2-3 Times per month
- ☐ Once per month
- ☐ Once every few months
- ☐ 1-2 times per year
- ☐ Never

4.2 Do you use video/digital games for instructional purposes with your students?

- ☐ Daily
- ☐ 2-4 Days per week
- ☐ Once per week
- ☐ 2-3 Times per month
- ☐ Once per month
- ☐ Once every few months
- ☐ 1-2 times per year
- ☐ Never

→ *If answered with "never", participants will proceed to 4.6 directly. Otherwise, questions 4.3 to 4.5 apply.*

4.3$_{optional}$ What types of digital games do your student play most during class time? (***Select one)***

- ☐ Educational Games (e.g., Filament Games, Poptropica, Mangahigh.com, PBS)
- ☐ Commercial off-the-shelf games (e.g., SimCity, Civilization, World of Warcraft)
- ☐ Entertainment games adapted for education use (e.g., SimCityEDU, Portal 2, MinecraftEDU)
- ☐ Other, please indicate: _____

4.4$_{optional}$ List the titles of up to three digital games you use with your students.

_____

_____

_____

4.5$_{optional}$ What are the primary reasons you use digital games in class? *(Select all that apply)*

- ☐ To present tasks
- ☐ To provide information/content
- ☐ To practice material already learned
- ☐ To trigger and support learning processes
- ☐ To provide a tool for knowledge acquisition
- ☐ To provide a tool for the processing of data
- ☐ To provide a subject for the students to analyze
- ☐ To provide material for self-organized work
- ☐ To provide a tool for communication and collaboration
- ☐ To provide a tool for saving and presenting learning results
- ☐ To give students a break activity
- ☐ To conduct assessments
- ☐ Other, please indicate: _____

4.6 At your school, what are the greatest barriers teachers face in using digital games in the classroom? *(Select all that apply)*

- ☐ Insufficient time
- ☐ Cost
- ☐ Lack of tech resources
- ☐ Not sure where to find quality games
- ☐ Not sure how to integrate games
- ☐ Unfamiliar with technology
- ☐ Hard to find games that fit curriculum
- ☐ Lack of administrative support
- ☐ Emphasis on standardized test scores
- ☐ Lack of parental support
- ☐ Low quality in graphics or audio effects in educational games
- ☐ There are no barriers
- ☐ Other, please indicate: _____

5. Attitudes and Expectations

Please rate the following statements:

5.1 I am comfortable with the idea of using digital games as tools for teaching educational content.

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

5.2 I believe I am capable of using digital games to deliver educational content in my teaching.

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

5.3 I believe digital games can be useful tools to teach educational content for the following reasons:

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5.3.1	They are fun for the students.					
5.3.2	They are hands-on for the students.					
5.3.3	They are motivating for the students.					
5.3.4	They increase the students' classroom engagement.					
5.3.5	I myself played games and I learned through gaming.					
5.3.6	I enjoy incorporating new digital technologies into teaching.					
5.3.7	Nowadays students are more attuned to learning with digital media or new technologies.					
5.3.8	They bring me into a better position among classroom teachers who are interested in using digital technologies for teaching.					
5.3.9	Digital games are easy to set up to facilitate classroom teaching and learning.					
5.3.10	Digital games provide me with another platform to engage my students in learning.					
5.3.11	They promote personalized learning.					
5.3.12	They can promote learning in STEM (science, technology, engineering, mathematics).					
5.3.13	Using digital games helps me relate to my students.					
5.3.14	They promote cognitive learning.					
5.3.15	They promote collaborative learning.					
5.3.16	They help increase content knowledge acquisition.					
5.3.17	They can be used as rewards when students do well in class.					
5.3.18	They can be used to promote learning objectives that meet curriculum requirements.					
5.3.19	They can be used as supplemental learning materials.					
5.3.20	Digital games bridge the gap between what students do at home and at school.					
5.3.21	They improve student attitudes toward the content.					
5.3.22	They increase student motivation to learn the content.					

5.3 Please summarize briefly what you expect from our project **for your students**, e.g. in terms of student motivation, learning outcomes etc.

_____

5.4 Please summarize briefly what you expect from our project **for you as a teacher**.

_____

Thank you for your participation!

Main Sources

Schnell, R., Bachteler, T., & Reiher, J. (2010). Improving the use of self-generated identification codes. Evaluation Review, 34(5), 391-418.

Takeuchi, L. M., & Vaala, S. (2014). Level up learning: A national survey on teaching with digital games. New York: The Joan Ganz Cooney Center at Sesame Workshop.

Tulodziecki, G., Herzig, B., & Grafe, S. (2010). Medienbildung in Schule und Unterricht. Grundlagen und Beispiele. Bad Heilbronn: Julius Klinkhardt.

Wu, M. L. (2015). Teachers' experience, attitudes, self-efficacy and perceived barriers to the use of digital game-based learning: a survey study through the lens of a typology of educational digital games. Dissertation. Michigan State University.

Yurek, L. A., Vasey, J., & Havens, D. S. (2008). The use of self-generated identification codes in longitudinal research. Evaluation Review, 32(5), 435-452. doi: 10.1177/0193841x08316676

Posttest Questionnaire

0. Self-generated identification code

The following 6-digit code will allow us to match your answers from the first and the second survey and will keep your data anonymous at the same time. No identification will be possible.

Please generate your code from following three questions:

What day of the month is your birthday? (Two characters)

First two letters of your mother's first name.

Your father's birth year (two characters)

→ _____

(Example: if your birthday was May 8th, 1975, and your mother's first name was Julia, and your father was born in 1950, then your code would be 08ju50.)

[Dropdown Menu with Codes from Survey 1]

1. Attitudes and Expectations

Please rate the following statements:

1.1 I am comfortable with the idea of using digital games as tools for teaching educational content.

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

1.2 I believe I am capable of using digital games to deliver educational content in my teaching.

- ☐ Strongly disagree
- ☐ Disagree
- ☐ Neutral
- ☐ Agree
- ☐ Strongly agree

1.3 I believe digital games can be useful tools to teach educational content for the following reasons:

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.3.1	They are fun for the students.					
1.3.2	They are hands-on for the students.					
1.3.3	They are motivating for the students.					
1.3.4	They increase the students' classroom engagement.					
1.3.5	I myself played games and I learned through gaming.					
1.3.6	I enjoy incorporating new digital technologies into teaching.					

		Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1.3.7	Nowadays students are more attuned to learning with digital media or new technologies.					
1.3.8	They bring me into a better position among classroom teachers who are interested in using digital technologies for teaching.					
1.3.9	Digital games are easy to set up to facilitate classroom teaching and learning.					
1.3.10	Digital games provide me with another platform to engage my students in learning.					
1.3.11	They promote personalized learning.					
1.3.12	They can promote learning in STEM (science, technology, engineering, mathematics).					
1.3.13	Using digital games helps me relate to my students.					
1.3.14	They promote cognitive learning.					
1.3.15	They promote collaborative learning.					
1.3.16	They help increase content knowledge acquisition.					
1.3.17	They can be used as rewards when students do well in class.					
1.3.18	They can be used to promote learning objectives that meet curriculum requirements.					
1.3.19	They can be used as supplemental learning materials.					
1.3.20	Digital games bridge the gap between what students do at home and at school.					
1.3.21	They improve student attitudes toward the content.					
1.3.22	They increase student motivation to learn the content.					

2. Your Game

2.1 Did you work with Arté: Mecenas or with Variant: Limits?

- Arté: Mecenas
- Variant: Limits

2.2 How many classes did you involve into this project?

- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5

3. Classes

3.1 Please characterize your project class: ***(to be filled in for each class, fields provided according to the number of classes as indicated in 2.2)***

- How old are the students in your project class? _____
- Which grade is this class in? _____
- How many students are there in this class? _____

- Please characterize your learners in this class briefly (e.g., attention/focus issues, gifted and talented, ect.). _____
- In which subject did you implement the game with this class? _____
- How long did you use the game in this class (hours and weeks)? If you are still working with the game, please estimate the total time you will have spent at the end of the project: _____

4. Your Experience with Arté: Mecenas or Variant: Limits

In the following, you will find a number of questions about your experience with the game. Of course, all students are individual and different from each other, and you may have made different experiences in different classes. Please relate your answers to the majority of your students and express the views that apply to most of them. If there were differing experiences with different classes, please tick all options that reflect your experiences in all classes.

4.1 Where did you implement the game: at home or at school?

- ☐ Students played in school lessons only
- ☐ Students played at school and at home
- ☐ Flipped classroom: students played at home only/mainly; instructions, questions, reflections etc. were discussed in class
- ☐ Students played at home only
- ☐ Other: _____

4.2 What was the main purpose of the game use in your class/classes? (*Tick all that apply*)

- ☐ To present tasks
- ☐ To provide information/content
- ☐ To practice material already learned
- ☐ To trigger and support learning processes
- ☐ To provide a tool for knowledge acquisition
- ☐ To provide a tool for the processing of data
- ☐ To provide a subject for the students to analyze
- ☐ To provide material for self-organized work
- ☐ To provide a tool for communication and collaboration
- ☐ To provide a tool for saving and presenting learning results
- ☐ To give students a break activity
- ☐ To conduct assessments
- ☐ Other, please indicate: _____

4.3 How did you introduce the game to your classes? (*Tick all that apply*)

- ☐ I let the students discover the game on their own
- ☐ I created additional material for the introduction
- ☐ I showed and explained the students how to play
- ☐ Other introduction: please specify: _____

4.4 In which kinds of social settings did your students play? (*Tick all that apply*)

- ☐ Individually
- ☐ In pairs
- ☐ In small groups
- ☐ With the whole class
- ☐ With parents
- ☐ Other social setting: please specify: _____

4.5 Which teaching and learning activities did you use in connection with the game? (*Tick all that apply*)

- ☐ Activities which prepare contents and provide information needed for the game
- ☐ Activities which prepare students to operate the game
- ☐ Activities which repeat contents from the game
- ☐ Activities which enhance, deepen and/or amend contents from the game
- ☐ Activities which allow for reflection on game-based learning as a learning method
- ☐ Assessment activities
- ☐ I did not use extra activities
- ☐ Other activities, please specify: _____

4.6 Which barriers, problems or difficulties did you face? (*Tick all that apply*)

- ☐ Insufficient time
- ☐ Lack of tech resources
- ☐ Not sure how to integrate the game into my lesson
- ☐ I am generally unfamiliar with technology
- ☐ Technical problems with the game (setting up accounts, saving game files, etc.)
- ☐ The game did not fit into my curriculum
- ☐ Lack of administrative support (at school)
- ☐ Lack of administrative support (on the part of Triseum)
- ☐ Lack of parental support
- ☐ Low quality in graphics or audio effects in the game
- ☐ Problems with the contents of the game
- ☐ Problems with student acceptance
- ☐ Problems with student behavior (e.g., trial & error, taking things not serious, etc.)
- ☐ Language
- ☐ There were no barriers
- ☐ Other, please indicate: _____

4.7 How easy was it for you as a teacher to operate the game (technically)? (Very easy – easy – neutral – hard – very hard)

4.8 How easy was it for your students to operate the game (technically)? (Very easy – easy – neutral – hard – very hard)

4.9 How easy was it for you as a teacher to integrate the game into your lessons? (Very easy – easy – neutral – hard – very hard)

5. Game impact

5.1 In the following, you will find a number of statements on the **impact that the game had on your students**.

How do you agree with the following statements? (Strongly disagree / disagree / neutral / agree / strongly agree)

- The game had a positive impact on my students' motivation.
- I think that my students found the interface design of the game eye-catching.
- I think that my students found the design of the game dry and unappealing.
- I think that my students enjoyed the game so much that they wanted to know more about the topic.
- I think that my students found the contents of the game useful to themselves.
- I think that my students found the activities in the game too difficult.
- I think that my students could not really understand quite a bit of the material in the game.
- I think that my students learned some things that were surprising or unexpected with the game.
- I think that the wording of feedback after the exercises, or of other comments in the game, helped my students feel rewarded for their effort.

5.2 How do you agree with the following statements concerning student classroom engagement? (Strongly disagree / disagree / neutral / agree / strongly agree)

- The game had a positive impact on my students' **behavioural engagement** (e.g., they showed high on-task attention and concentration, high effort, and high persistence, especially on difficult tasks).
- The game had a positive impact on my students' **emotional engagement** (e.g., they showed frequent and strong positive emotions (interest, joy and curiosity) and infrequent negative emotions (anger, boredom and discouragement)).
- The game had a positive impact on my students' **cognitive engagement** (e.g., they used sophisticated learning strategies, were planful and strategic learners, and monitored, checked and evaluated their work).
- The game had a positive impact on my students' **agentic engagement** (e.g., they offered suggestions, asked questions, expressed interest, preferences, and likes vs. dislikes).

5.3 My students acquired content knowledge from the game. (Strongly disagree / disagree / neutral / agree / strongly agree)

- Please outline briefly all kinds of content knowledge that your students acquired (e.g., historical knowledge, knowledge about arts, knowledge about limits, knowledge about functions, etc.): _____

5.4 How do you agree with the following statements? (Strongly disagree / disagree / neutral / agree / strongly agree)

- My students acquired social/communication skills from the game.
- Most of my students liked the game.
- Weaker students benefited greatly from the game.
- Average students benefited greatly from the game.
- Stronger students benefited greatly from the game.
- Boys benefited greatly from the game.
- Girls benefited greatly from the game.
- Students who are frequent gamers benefited greatly from the game.
- Students who rarely or never play games benefited greatly from the game.
- I discovered different or additional effects on my students: please explain: _____

6. Future perspectives, expectations, and overall rating

6.1 What do you think with regard to future perspectives? (*Tick all that apply*)

☐ I would recommend the game to a colleague
☐ I intend to use the game again

6.2 I would like to see the following improvements to the game (technically): _____

6.3 I would like to see the following improvements to the game (with regards to contents):

- _____

6.4 In the beginning of the project, you had certain expectations related **to your students**, e.g. in terms of student motivation, learning outcomes etc. Please explain in how far these expectations were met.

_____

6.5 In the beginning of the project, you had certain expectations related **to yourself as a teacher**. Please explain in how far these expectations were met.

_____

6.6 In the course of the project, which unexpected reactions, changes and surprises occurred?

_____

6.7 How do you rate the overall success of the game in your class or classes?
Very successful / rather successful / neutral / rather unsuccessful / very unsuccessful

Please explain your rating:

_____

6.8 Is there anything else you would like to add?

_____

Thank you for your participation!

Main Sources:

Huang, W.-H., Huang, W.-Y., & Tschopp, J. (2010). Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. ***Computers & Education 55***, 789-797.

Lee, W., & Reeve, J. (2012). Teachers' estimates of their students' motivation and engagement: being in synch with students. ***Educational Psychology: An International Journal of Experimental Educational Psychology, 32***(6), 727-747.

Takeuchi, L. M., & Vaala, S. (2014). ***Level up learning: A national survey on teaching with digital games***. New York: The Joan Ganz Cooney Center at Sesame Workshop.

Tulodziecki, G., Herzig, B., & Grafe, S. (2010). ***Medienbildung in Schule und Unterricht. Grundlagen und Beispiele***. Bad Heilbronn: Julius Klinkhardt.

Wu, M. L. (2015). ***Teachers' experience, attitudes, self-efficacy and perceived barriers to the use of digital game-based learning: a survey study through the lens of a typology of educational digital games***. Dissertation. Michigan State University.

10.2 Variant: Limits: missing contents

In the context of missing contents, one teacher explained in more depth what content is missing:

> ***"I think that the game totally skips the part about the problem of infinity, which is the big issue in limits. So, I really had to… Not to stop the game, but in-between… When you reach the end of zone three, and you pass to zone four, then infinity comes up. [chuckling] So, it's just like you're rear-ended out of the car. I don't really think this can be done in this way. You have to bring them to the idea of infinity, and infinitesimal, and that's a big issue with limits, and it would be the turning point around potential and actual infinity, the role of infinity in our culture… It's not just math. It's philosophy, art, it's everything. Logic. They have already met this idea, because if you start with the circumference approximation, the exhaustive method, or the problem of irrational numbers, they have had glimpses of infinity, but now we have to give a name to this thing, and to learn how to deal with this thing. So, I think that the game is not complete in this way. So, it underestimates the problem about infinity. It should be… I wouldn't want other materials to come with the game, but somehow a prompt for the teacher saying, 'Pay attention. Infinity is ahead.' […]***
>
> ***Here is not even a word about indeterminate forms. I mean, how can we teach our students that the limit of the quotient is the quotient of the limits, without making them aware that this sentence is not always true? I mean, in the mathematical point of view, this sentence is false, because in mathematics you don't have 'not always true.' It's either true or false. If I say this sentence, as it's written in the game, is false, I have to make them well aware of it. If you have zero over zero, the limit of the quotient is not the quotient of the limits. […]***
>
> ***So, [I created an activity] to pinpoint that if you have zero over zero, or infinity over infinity, pay attention. These laws do not apply. Don't you think it's a missing part? Totally missing?"***

10.3 Focus Group Outline

Background information and purpose of study

The focus groups are part of the Triseum pilot project which pilots the two learning games *Arté: Mecenas* and *Variant: Limits* at schools in five European countries. The project is organized by European Schoolnet and evaluated by the University of Würzburg. Project runtime is from July 2017 to June 2018.

The evaluation activities include a pre- and a post-questionnaire as well as the focus groups to gather information on the following research questions:

1. Does game-based learning increase student motivation to learn and classroom engagement?
2. How is game-based learning implemented within a K-12 environment?
3. Do students gain content knowledge from playing serious games that are integrated into lesson plans?

In this context, the focus groups are an important means to collect qualitative data. The results will be published in the final evaluation report in June 2018.

Focus group organization

- **Place and time:** 17. & 18. Feb. 2018, at EUN, in the context of Workshop meeting.
- Teachers have started working with the games in their classes and will be able to share their experiences.
- **Duration:** 2 hours per focus group
- **Groups:** 4 focus groups, with 5 participants each (see Appendix A)
- **Participant selection:** No participant selection and invitation necessary. The participants will be the group of pilot teachers involved in the project.
- **Monetary incentives:** Participants are invited for the weekend in Brussels, including flights, meals, and accommodation.

Focus group session requirements

- **Facility requirements:** The focus groups need to be conducted in a room which is equipped for recording the session. The session will be video or audio recorded. Further requirements include a flipchart or board or similar.
- **Moderation:** The focus groups will be moderated by Jennifer Tiede and Prof. Dr. Silke Grafe, who will function as one moderator and one assistant moderator.
- **Further personnel:** It is desirable to keep outsiders present in a focus group session to a minimum to facilitate an uninfluenced and lively discussion.

Questioning Route

The following questioning route was developed following Krueger and Casey, 2015, p. 60-71:

1) Brainstorming, 2) Sequencing the questions, 3) Phrasing the questions, 4) Estimating time for each question, 5) Getting feedback from others, 6) Revising the questions, and 7) Testing the questions (performed as an intense and iterated reflection and revision within the project team).

No.	Time	Type	Question	Prompts
	0-0.10	*Welcome time, smalltalk, etc.; Introduction*		
1	**0.10-0.15**	Opening q.	Please tell us who you are and what you teach and please introduce your project classes in a few words.	
2	**0.15-0.20**	Introductory q.	Think back to the last years. What experiences have you made with game-based learning, either digital or analog, before the Triseum project?	
3	**0.20-0.40**	Key q.: Implementation	How did you integrate [Variant: Limits/Arté: Mecenas] into your lessons?	Teaching and learning activities Reflection on game-based learning with students Preparation with students Introduction: with explanation or exploratory? Length: how many lessons? Integration into curriculum Technical realization: media rooms or BYOD Use in class or at home? Student reactions Assessment
4	**0.40-0.50**	Key q.: implementation	When you used [Variant: Limits/ Arté: Mecenas] in class, what went particularly well?	
5	**0.50-1.05**	Key q.: Implementation	Which difficulties did you face during the implementation so far, and how did you overcome these?	Technical problems Acceptance Curriculum fit Language Lack of skills required (both teacher and student skills)

No.	Time	Type	Question	Prompts
6	**1.05-1.25**	Key q.: motivation, classroom engagement, knowledge gain	Which effects did [Variant: Limits/ Arté: Mecenas] have on your students?	Motivation Classroom engagement Knowledge gain How did you recognize or measure these effects? Reluctance / Resistance Different effects on different types of student?
7	**1.25-1.35**	Optional q.: Future perspectives	Imagine you want to use [Variant: Limits/Arté: Mecenas] again next year. What do you think would be necessary to make the implementation of [Variant: Limits/ Arté: Mecenas] in class even more successful?	In-game improvements Selection of classes Technical realization Pedagogical concept Improvement of own mistakes
8	**1.35-1.50**	Ending q.	Consider all the aspects that were discussed today. How do you rate the overall success of the game in your class or classes?	Very successful, rather successful, neutral, rather not successful, absolutely not successful Which factors led to your assessment? Which aspect was of great importance for you?
9	**1.50-2.00**	Ending q.	Have we missed anything?	New aspects you would like to talk about?
		Summary, Goodbye, Thank you		

Literature

Krueger, R.A., & Casey, M.A. (2015). Focus Groups. A Practical Guide for Applied Research. 5th ed. Los Angeles, London, New Delhi, Singapore, Washington D.C.: Sage.

Liamputtong, P. (2011). Focus Group Methodology. Principles and Practice. London, Thousand Oaks, New Delhi, Singapore: Sage.

Litosseliti, L. (2003). Using Focus Groups in Research. London, New York: continuum.

10.4 Future Classroom Scenarios

Triseum Pilot teachers developed innovative scenarios and learning activities that include the Triseum games. Following the Future Classroom Lab methodology, the learning scenarios illustrate how the two Triseum games were implemented in classrooms in the 5 pilot countries and highlight the array of learning objectives which can be achieved by introducing ARTé: Mecenas and Variant: Limits in learning settings.

The list of game-based learning Future Classroom Scenarios developed by the Triseum Pilot teachers is provided below.

Future Classroom Scenarios with ARTé: Mecenas

- ARTé: Mecenas: Getting started - Learning the game mechanics – Authors: Vegard Relling and Gaute Hauge (Norway)
- Be like the Medici! – Authors: Agnieszka Pielorz (Poland)
- New strategic planning towards art history learning - ARTé: Mecenas – Authors: Alberto Figueiredo (Portugal)
- Decision Making In History - act as a Medici! - Authors: Alberto Garniga (Italy)
- Art history as the history of the patronage – Authors: Anita Streich (Poland)
- Story Time! – Authors: Anita Streich (Poland)
- Art Economics: Past and Present – Authors: Evangelia Karimali (Greece)
- #Art&power – Authors: Francesca Pellegrino (Italy)
- Using ARTé: Mecenas to teach European Middle Age history – Authors: Gaute Hauge and Vegard Relling (Norway)
- ARTé: Mecenas: a new approach to art history learning – Authors: Maria Durão (Portugal)
- Art and Power Relations - From Ancient Greece to the Medici Family – Authors: Despoina Poimenidou (Greece)

Future Classroom Scenarios with Variant:Limits

- No Limits to Learning! Variant: Limits game in the classroom - Authors: Annamaria Lisotti (Italy)
- One-sided limits – Authors: Anna Sulek (Poland)
- Learning to play with Variant: Limits – Authors: Carminda Meireles, Paula Santos (Portugal)
- Exploring Limits in a Game – Authors: Geir Myhr, Håvard Hatlevik (Norway)
- The sky is the Limit - A Learning Scenario for Variant: Limits – Authors: Giulia Bini (Italy)
- Exploring limits with Variant: Limits – Authors: Håvard Hatlevik, Geir Myhr (Norway)
- Introduction to Variant Limits - first lesson with the game – Authors: Michał Głatki (Poland)
- Approaching the concept of Limits of Functions - Authors: Panagiota Argyri (Greece)
- Law of Limits – Authors: Panagiota Argyri (Greece)
- Triseum games – reaching the infinite – Authors: Panagiota Argyri (Greece)
- Game Win – Authors: Carminda Meireles and Paula Santos (Portugal)

Triseum Game-Based Learning Validation Study

EVALUATION REPORT

In May 2017, Texas-based Triseum joined the Future Classroom Lab and became the first industry partner to have game-based learning as its core business. As part of its membership of the Future Classroom Lab, Triseum asked European Schoolnet to run a validation pilot involving use of two of its learning games (ARTé: Mecenas™ and Variant: Limits™) in schools in several European countries. Over the course of almost one year, 20 teachers from schools in Greece, Italy, Norway, Poland and Portugal used the games in their teaching and took part in the evaluation.

Learn more at: http://fcl.eun.org/triseum-validation-pilot

futureclassroomlab | fcl_euschoolnet

European Schoolnet — www.europeanschoolnet.org

triseum™ — triseum.com

Julius-Maximilians-UNIVERSITÄT WÜRZBURG — www.uni-wuerzburg.de