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The Case of a Multiplication Skills Game: Teachers' Viewpoint on MG's Dashboard and OSLM Features

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Abstract: Educational games and digital game-based learning (DGBL) provide pupils interactive, engaging, intelligent, and motivating learning environments. According to research, digital games can support students' learning and enhance their motivation to learn. Given the central role teachers play in the learning process, their perceptions of DGBL play a significant role in the usage and effectiveness of game-based learning. This paper presents the main findings of an online research on primary school teachers' attitudes toward DGBL. Furthermore, the research investigates teachers' opinions about the functionalities provided by the implemented Multiplication Game (MG) and the newly incorporated teacher dashboard. The MG is an assessment and skills improvement tool that integrates an adaptation mechanism that identifies student weaknesses on the multiplication tables and in its latest version also supports a strong social parameter. Students can be informed about their own progress as well as the progress of their peers in an effort to examine if social interaction or competition can increase players' motivation, which is a subject that raised some concerns in the teaching community. The paper describes the functional options offered by the MG dashboard and documents the outcomes of an online survey conducted with the participation of 182 primary school teachers. The survey indicated the potential usefulness of MG and the benefits it can offer as a learning tool to improve pupil multiplication skills and help teachers identify individual pupil skills and difficulties and adapt their teaching accordingly. The analysis applied has found a correlation between teachers' perceptions about MG and their view on using digital games in general.

Keywords: digital game-based learning; media in education; multiplication game; digital games usefulness

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Citation: Leonardou, A.; Rigou, M.; Panagiotarou, A.; Garofalakis, J. The Case of a Multiplication Skills Game: Teachers' Viewpoint on MG's Dashboard and OSLM Features. *Computers* **2021**, *10*, 65. https://doi.org/10.3390/computers10050065

Academic Editors: Carlos Vaz de Carvalho and Antonio Coelho

Received: 4 April 2021
Accepted: 13 May 2021
Published: 17 May 2021

1. Introduction

According to Prensky [1], what allures nowadays children to participate in video and computer games is neither violence nor their subject but the provided learning. Children similar to all humans enjoy learning when the notion of obligation is missing. Through modern computer and video games, game players not only become familiar with ways to use games and act inside the game theme and plot but are also offered opportunities of metacognitive learning (p. 2):

> "to take in information from many sources and make decisions quickly; to deduce a game's rules from playing rather than by being told; to create strategies for overcoming obstacles; to understand complex systems through experimentation"

Furthermore, players learn to interact and cooperate with others while developing a social consciousness.

Today's game-players at their mid-school age are already capable of comprehending and possess a remarkable fluency in doing many complex things (e.g., reasoning, building, flying); therefore, the typical school curriculum is considered rather unattractive and disengaging. Consequently, it is crucial that teachers try hard to keep up with their students' digital pace and even to embrace their online capabilities through designing appropriately the whole teaching form [1]. Furthermore, during the COVID-19 pandemic, digital educational games have earned a significant role through distance learning settings (either synchronous or asynchronous) deployed for considerable periods of time in educational systems around the world. Educational games and digital game-based learning (DGBL) offer pupils learning environments that are interesting, engaging, intelligent, adaptive, motivating, and interactive, where pupils can communicate their knowledge, experiences, feelings, and thoughts [2–4].

This paper, starting from game-based learning theory attempts to offer an insight of teacher perception and acceptance of digital games in general, and the Multiplication Game (MG) in particular. MG is a digital assessment tool, and part of its usefulness results from the incorporated logic of DGBL. Furthermore, it is designed to promote flow experience that fosters learners' enjoyment and concentration. Student motivation is developed by incorporating the Open Learner Model notion, as parts of the underlying user model are exposed to pupils in a graphically simplified form. Moreover, MG shares a social aspect as the learner model does not open exclusively for the particular pupil but also for the teacher and class pupils through adequately designed views. This study focuses on revealing pupil's information to the teacher via a dashboard where the teacher can monitor the progress of individual pupils and the whole class on multiplication skills. The objective of the conducted survey was to investigate the perceptions teachers have toward the opening of pupil progress data to the pupil they concern and to peers, and also their attitude toward the benefits and support MG can provide to their teaching. Moreover, the survey recorded the teachers' views of the MG in relate with their views on DGBL.

2. Digital Games and DGBL

Undoubtedly, modern pupils impose high demands on the technological aspects of their learning as they do not consider traditional educational approaches as interesting and require up-to-date learning environments and tools. Game-based learning is the pedagogical approach that makes use of games offering pupils the opportunity to take part in the educational process and material in an active and enjoyable way [5]. Game-based learning comprises the design and development of game activities targeting interactive learning and supporting pupils to gradually apprehend concepts and be guided toward a final goal [6]. At the same time, pupils are experiencing feelings of achievement, reward, and progression. Game-based learning can be utilized as a teaching method because through game content and plot, pupils can explore the various game parts, using them as ways of knowledge acquisition and skills enhancement [7,8]. Based on similar observations, Prensky [1] supported that educational software design should take its shape using game design methods and techniques. This belief is widely respected, and its popularity is growing [4]. Nevertheless, educators should be cautious about the frequency of deploying digital games in their teaching practice, as many of today's children already make excessive use of digital games, which leads to problematic habits such as lower physical activity, fewer social interactions, poor sleep patterns [9], or even substance addiction symptoms e.g., craving, mood changes, tolerance, and salience [10,11]. Still, the potential benefits of digital educational games outnumber their side effects and cannot be considered as a reason to exclude digital games from the classrooms.

Digital games span a wide range of categories, use a variety of digital technologies (e.g., computers, (handheld) consoles and mobile devices) [12], and their popularity is steadily rising [13,14]. Digital educational games are defined as "computer-assisted instructional tools and techniques in which skills and chance are combined and implemented on previously acquired information and experiences developing thus, engaging and immersive learning experiences in order to achieve specific learning goals, outcomes and experiences" (p. 120) [7]. Moreover, digital educational games support adaptability and foster situated learning environments where students through playing obtain and exchange knowledge and skills [2,15]. As digital games provide a virtual environment, they support students to overcome the limitation of physical space and offer hands-on access to learning materials [16]. According to Li [17], digital game creation and the engagement in them can result in active students, which will therefore lead in developing 21st century skills and supporting more effective and thorough curriculum understanding. Furthermore, according to [18], digital games help players develop skills such as "critical thinking and problem solving, teamwork and communication, creativity and innovation, and technology proficiency" (p. 421). Through digital gaming, pupils that initially possessed only the ability of applying pre-arranged solution strategies are gradually guided to develop the ability to comprehend original solution strategies [19]. Digital games can offer "opportunities for investigating and understanding real-world situations" (p. 24) [14]. According to [4], they provide an effective and motivational approach to support pupils' learning, while they can significantly improve knowledge transfer, increasing student enjoyment and interest on the particular subject.

According to [7,20], digital educational games when used as a teaching and learning tool can lead to:

- Promotion of pupil engagement, learning motivation, enjoyment and eagerness [1,21–23],
- Improved academic attainments and socialization of pupils [24,25],
- Increase of higher-order thinking skills, development of critical thinking, and promotion of cooperation among peers (i.e., classmates) [26,27],
- Positive influence on pupil creativity, problem-solving skills, spatial ability, and conceptual understanding [28,29].

Research studies support that game-based learning can be even superior to traditional classroom instruction as it enhances the motivation to learn, while offering opportunities to explore and acquire new knowledge and skills [8,30,31]. DGBL is a student-centered learning approach that unites digital games with educational material to provoke pupils' interest, while they are given the opportunity to empower their learning efficacy. As a result, pupils face knowledge acquisition and education in general, positively. Games designed according to these principles give pupils the chance to practice their skills in a virtual and safe environment, enhance collaboration, promote communication, and develop cognitive and soft skills [7].

3. Teachers' Attitude toward Digital Games

Shifting from the traditional form of teaching to teaching that includes using digital educational games in the classroom is considered to be a significant change [32]. According to Fullan [33], the implementation of an educational change is determined by three factors: (1) the characteristics of the change (e.g., if the change is useful, practical, and not complicated or long), (2) local characteristics (the district, the community, the principal, the teachers, etc.); and (3) external factors (government, other agencies, etc.) [32]. The adoption and the effectiveness of game-based learning depend largely on the grade of acceptance by classroom teachers [34,35], as they can be considered the true change agents of the schools [36]. Therefore, it is crucial to obtain an insight on teachers' perceptions and beliefs that guide their decision-making process. If teachers have negative perceptions about using DGBL, this can proved a significant obstacle against technology integration and against using digital games for learning [37,38].

Among models that examine and predict teachers' behavior stands out the Technology Acceptance Model (TAM) [39]. According to the TAM model, the acceptance of any technology can be predicted by (a) its perceived usefulness and (b) its ease of use. Furthermore, the TAM model highlights the correlation between these two factors: a technology is considered to be more useful if it is easier to use. In the field of educational research, it is observed that teachers will use a technology in the classroom, only if they are convinced about the advantages (on an administrative and teaching level) this technology can offer [40].

In an effort to summarize the main findings from studies such as [37,41–43] on digital games' adaptation in formal education, major points can be categorized under the following three axes:

1. Teachers' perceptions of the value of incorporating digital games in the classroom. More analytically according to teachers' beliefs, the main reasons to use digital games in the classroom are the following:
    - To enhance student motivation [3,42,44–47]
    - To support students' acquisition of knowledge and cognitive skills [42,44,45]. These beliefs regarding learning opportunities have the strongest direct effect on teachers' intentions to use games [38,48]
    - To offer students a safe learning environment where the consequences of failure are smoother [49]
    - To empower students' activeness [48],
    - To offer students feedback on their learning skills and actions [48],
    - To visualize students' progress for them to watch [48],
    - To propose additional learning material or a reward [37],
    - To entertain students [37],
    - To support evolvement as digital games are considered 'the future' (teachers support the belief that the adoption rate of game-based learning will continue to speed up in the very immediate future [37]).
2. Teachers' acceptance that games play an important role in their teaching procedure. Acceptance of digital games by teachers depends on many factors:
    - Teachers who experience playing games in their spare time are interested in the idea of digital games in their teaching process [45,50–52], while teachers' ability to effectively deal with new technologies does not necessarily imply that they support the idea of digital games in the classroom [37,45]
    - Degree of relevance (according to teachers) games have to their educational practice [34,41,44,51]
    - Usefulness and learning opportunities offered by the game [37],
    - Aspects in the social environment of teachers (students, colleagues, principal) [37,50,53],
    - Teachers' own experience, which has convinced them about the positive consequences of technology [48],
    - Pupil competition during game play [47], as this can be a reason for using games in the classroom [48,54].
3. Teachers' perceptions on barriers against using games in the classroom. The main factors that discourage teachers from using digital games may be the following:
    - Lack of time and technical issues [34,47,52],
    - Inflexibility of the curriculum or fixed class schedules [32,52], that makes teachers feel restricted and unwilling to try non-conservative ways of teaching,
    - Perceived negative effects of gaming e.g., addiction, emotional suppression, repetitive stress injuries, relationship issues, social disconnection [32],
    - Unprepared students [32] that delay teaching, as without adequate preparation at home, students cannot cope with the subject and concepts, and therefore, they deprive the class of the opportunity to play games or the teacher needs to consume teaching time for repeating the same teaching material,
    - Absence of supportive materials to help teachers find the suitable digital game that is compatible with the subject and the class level and also offers proper usage instructions [29,32,52],
    - Limited budgets [32] that lead to poorly equipped computer school labs, etc.,
    - Teaching experience may affect the type of limitations teachers consider when they think about using games in the classroom [32,34], as older teachers are less willing to try non-traditional ways of learning due to their poor or incomplete technology-related skills [29,52],
    - Classroom management issues [41] that can vary but take away the opportunity from the teacher to deal with issues such as the adoption of digital games,

- Poor learning opportunities of the available games [34,41],
- Complexity of using games in the classroom, as access to required devices is required (PCs or smart devices) with the risk of distracting pupils from the teaching goals, although its relation to the other factors remains unclear [34,38,49,50],
- Teachers' own poor efficacy in using the technologies, in combination with anxiety toward scenarios of failure [52].

4. Adaptiveness and Open Learner Modeling

In the game world, it is crucial for a player to face challenges that are in close correspondence with individual skills' level. If the challenge is higher than the player can handle according to own skill level, then the player can feel anxiety or be discouraged. On the other hand, if the challenge is much lower than the player's skills level, it is possible that the player will feel bored and not engaged [55]. Adaptive are the games that possess an internal mechanism that stores data for every player individually and therefore can make inferences that match the needs and preferences of each player. If apart from maintaining data about the learners and their interactions, some of these elements are also exposed in a suitable way, a connection is set up between adaptive educational gaming and open learner modeling (OLM). OLM was introduced as a notion in the research field of intelligent tutoring systems and adaptive learning environments with the aim to support personalized instruction to learners. At first, adaptive systems did not give learners the chance to access the data stored in their learner model, but things changed when researchers and educators supported through experiments the educational gain that derives from such a revealing [56]. It was proved that by offering learners an insight into specific parts of their own user model, they could use this feedback to self-assess and also reflect on their current skills and competences, organize more effectively their learning, apprehend the system's adaptation decisions, and also demonstrate greater motivation to learn and improve [57–59].

Social OLM (OSLM or OSSM) is an extension of OLM [57,60], and its basic idea is to expose elements from a learner's model also to others, apart from the particular user the data refer to, e.g., instructors, peers, and parents. OSLMs can intensify OLMs' cognitive aspects via social aspects, as learners are given the opportunity to explore other individuals' model or summative information of a peers' group and support them through suitable content topics [61].

Different studies [62,63] support the opinion that when accessing peers' models, learners achieve a wider coverage of topics in the system and higher rates in self-assessment problems. In fact, the OSLM notion is in agreement with past research in the domain of social navigation, which can be utilized in order to guide users through the learning content by revealing other learners' paths and therefore replace knowledge-based guidance [64]. Another contribution of OLM and OSLM is that they contribute in promoting engagement to learning environment and content [61,65].

The choice of which information the user will access and in what way it will be represented are both central issues, as OLM and OSLM will not meet its practical value if the intuitiveness and ease of perception of the offered data are not assured. Therefore, visualization has a central role that determines the effectiveness of offered information such as the level of assessed knowledge and skills, or the difficulties/misconceptions encountered by the user [66]. Basically, all types of learner models can be opened to users, and the reason for this access will determine the technique of illustrating the model. Moreover, model data visualization depends on who will access these data (educators, parents, or peers) in combination with the purpose for using the information (i.e., context and tasks) [67].

5. OLM Visualization Options

OLMs are able to take over the responsibility for presenting learner model data in an understandable form, to allow for appropriate actions and decision making. Usually, internal learner model mechanisms and inference logic are too complicated to be presented to learners, peers, teachers, or parents without being processed or filtered; therefore, the simplification of learner model data is necessary through visual presentation [67]. Due to the many different usages and potential users accessing the model, various visualizations could be deployed to serve adequately the OLM purposes [68]. OLM visualizations may include data about the learner, data that compare the learner with peers (individuals or a group, e.g., best scoring classmates), data about other individual learner(s), or the average/summative performance of a complete class. A search in the related literature identifies a variety of available visualizations, namely:

- Bar Charts and Histograms usually represent learner performance, competencies level, and activity level (posts to forums, access frequency, content view durations, etc.).
- Pie Charts in OLMs are used similarly to bar charts, but they have limitations concerning the number of values and do not support detailed comparisons [69,70].
- Radar Plots [71] support easy comparisons and identification of outliers. A radar plot can be used to represent multiple learners and compare them on various dimensions (e.g., performance, activity level, topics covered), or it can also depict a single user.
- Scatterplots [72] can represent either a single learner (performance, activity level, topics covered, etc.) or compare multiple learners using different colors or point shapes.
- Tables are used to represent either a single learner (performance, activity level, topics covered, etc.) or multiple learners (each one in a different row or column).
- Timelines can depict information arranged on a time scale and convey trends (e.g., learner progress, learner access history) [73–75].
- Network Diagrams [70,71,76] are used to represent learner associations (learners are nodes and associations are edges) or content associations along with learner performance (topics are nodes and the way nodes are coded in color/size/shape denotes learner performance on each topic). When clicking on a node of the network, it may be expanded or collapsed to present more or less information [77].
- Tag/Word Clouds [70,76,78] present the level of competencies or weaknesses and can distinguish their respective degree (level).
- Skill Meters represent a simple overview of the learner model contents, which are typically found as a group of more than one skill meters assigned to each topic or concept. In addition, separate skill meters could be used for sub-topics allowing a simpler structure of the model presentation [79]. Most skill meters [71,76,80] display the learner level of knowledge, understanding, or skill compared to a subset of expert knowledge [79,81] in the form of proportion of the meter filled [76,82].
- Sunbursts are multi-level pie charts, which visualize hierarchical data, depicted by concentric circles [83]. The circle in the center represents the root node, with the hierarchy moving outward from the center. A segment of the inner circle bears a hierarchical relationship to those segments of the outer circle that lie within the angular sweep of the parent segment [84]. In OLMs, sunburst charts can present the complete learner model in concentric sectors. In some implementations, sunbursts are interactive, and the user can get more information describing the sources that support the current values, or the learner can access other sections related to a specific concept [85].
- Concept Maps depict ideas and information (concepts) as boxes or circles that are connected with labeled arrows in a downward-branching hierarchical structure [86,87]. Concept maps [78] can be pre-structured to reflect the domain, with the nodes indicating the strength of knowledge or understanding of a concept [88].
- Bullet Charts can be interactive and provide details concerning the way individual scores are calculated, and learners can view the tasks that contribute to a specific learning outcome and identify tasks that can improve their level. Bullet charts are typically unstructured OLM visualizations.

- (Hierarchical) Trees are typically used for depicting learning concepts and their structural relations along with annotations that refer to the current learner competencies [85,87,89,90].
- Treemaps depicts hierarchies in which the rectangular screen space is divided into regions, which are also divided again for each level in the hierarchy [91]. Through size, there is an indication of topics' strength, and typically, a learner can click on a cell to view the next layer in the hierarchical structure [77].
- Gauges depict learner skills on specific topics and can also integrate a scalar set of values representing discrete ranges, as in [64]. Each gauge represents a specific learner.
- Grids use color to indicate level of understanding [92] on a specific topic. They may display a single learner or multiple learners as in MasteryGrids [61] that use cells of different color saturation to show knowledge progress of the target student, reference group, and other students over multiple kinds of educational content organized by topics. Grids are unstructured OLM visualizations.
- Burn Down Charts graphically represent the remaining work versus time. In OLMs, through burn down charts, learners can track their own progress, showing target and projected completion time, percentage of assignments submitted and completed [66]. Thus, they are self-assessment tools keeping learners motivated and focused on their objectives.
- Task lists and focus lists (tasks to be focused on to stay on track) support student engagement with frequent formative feedback. The task list uses different colors in order to keep learners informed about the status of their task [66].

Visualization plays a crucial role in representing data from a learner model, as the appropriate match between data and type of visualization would result in users' better apprehension of the information. According to Bull and Kay [67], it is important to go through a phase simplification on learner model data when deciding the form of visualization being used for pupils, teachers, and parents, omitting complex details such as user monitoring details, inference logic deployed by the adaptation mechanism, etc. Different ways of visualization are recommended for different viewer roles, as different information is necessary in each case and should serve different purposes and user tasks [68]. When visually representing data, variations in fill, color position, and/or size can indicate differences in level of understanding, competencies, skills, and curricula coverage [92]. Most typical visualization types are bar charts, pie charts, radar plots, scatterplots, tables, timelines, network diagrams, and skill meters [93]. There are OLM-based systems that support multiple representations, as research has supported that users enjoy having control over the choice of visualization type, although some visualizations are more preferable [87,94,95].

When visualizing learner models in digital educational games, simple quantized representations are recommended, such as target–arrow, where the number of arrows depicts the level of knowledge for the specific topic (typically up to four levels) [64,96], smilies (smiley faces), where a smiley (or not) face with scalar variations represents knowledge level or contrast a learner's level with the level of peers [97], stars, where the number of stars presented or filled with color (from a fixed number of total stars typically 4–5) depicts learner skill level [77], liquid in a cup or container, where the amount of filled liquid depicts learner's skill level [81], growth of tree, where the different growth stages of the tree depict the different skill levels of a learner [98], and more.

For OSLMs, user model visualizations are selected on the basis of how well they can show social comparison (two individuals, one individual and a group, etc.) [60,61,92,99,100].

6. Multiplication Game Description

The MG is a web-based practice and progress monitoring game that serves educational and scientific purposes. It started out as an adaptive mobile application (v.1) [101], and it was extended as a desktop application with incorporated OLM elements (v.2) [102]. Followingly, it was revised by adding social characteristics to the OLM, as the learner model is now open apart from the learner, also to teachers and peers (v.3) [103]. The design and implementation of the MG is based on the belief that multiplication tables fluency is a very significant skill; therefore, it should be supported by engaging and motivational assessment tool. Since in this paper, the focus is placed on teacher support aspects, the game play is briefly described to provide an overview picture of the game, while the functionalities that are offered to teachers are presented in more detail.

6.1. Brief Description of MG

After the player logs into the game, (s)he can choose which number(s) to practice. The player goes through four levels with different types of questions in each one: (a) right or wrong, (b) multiple choice, (c) matching question with result, and (d) fill in the blank. With the completion of each level, the player can be informed about their own progress. Furthermore, the MG incorporates an adaptive algorithm that undertakes to make a diagnosis (after completing each level) of the player's main weakness and tries to "treat" this difficulty by supporting the player on this particular number in the next level. Upon the game finishing, the player has the option to access the overall progress in the specific game as well as compare the overall progress of the three most recent games. Student can also compare own progress with the average progress of their classmates and see the 5 high scorers in the class.

6.2. Description of MG's Teacher Daskboard

The MG offers teachers insight into their pupils' multiplication skills (progress/evaluation and history). By using the MG, a teacher can be discharged from the time-consuming correction of pupils' schoolwork on paper (or significantly reduce this effort) using instead the detailed data and progress record of each student maintained by the MG. Depending on teacher's selections, the MG collects selected data from the respective learner model (in the case of an individual student) or from multiple learner models (in the case of all the classmates), and they are presented in an adequate graphical form [104]. As already mentioned, visualization enables comprehension and communication [105], and it depicts a much clearer image for the human brain compared to words or numbers [106]. In this approach, data are presented mainly in the form of tables and barcharts [107]. The information presented via the dashboard is selected according to the criteria of supporting teachers to easily access and assess their pupils, self-assessing their teaching practice outcomes, expose common mistakes of the particular student group, identify low achievers (in order to be more supported) and also help to (re-)arrange teaching process in the special needs of the pupil group (based on the feedback by the above visualizations).

Through the MG dashboard, the teacher can monitor the progress of the pupils—the progress of each individual student either overall or for a selected training number—and keep track of the student's game dates, the selected numbers for each game, the overall success rate and mistakes, as well as the frequency of each mistake. Figure 1 depicts a dashboard instance where the teacher chose to see the overall activity of student named "Ζωή N.".

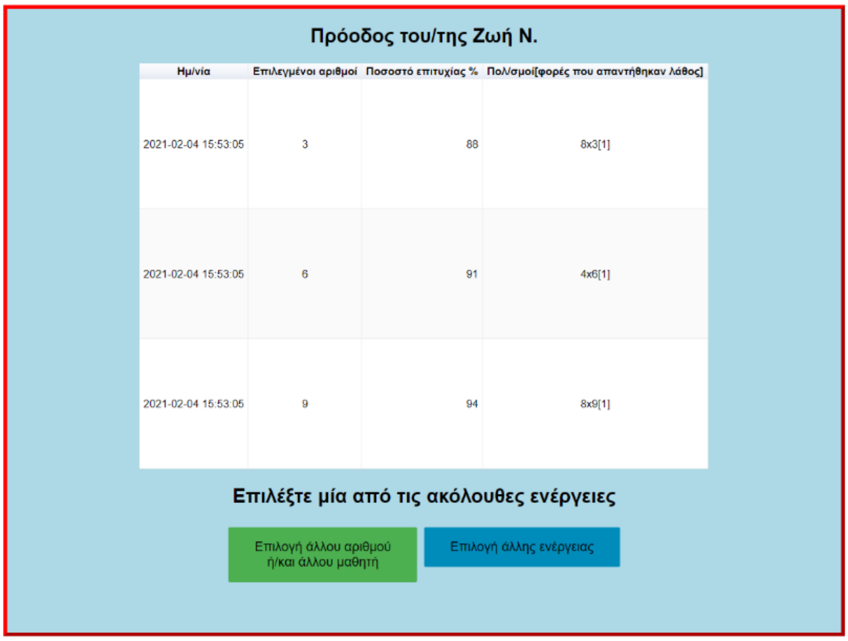


Figure 1. Individual student progress.

When selecting a specific number, the teacher can see on a bar chart the student's success rates in each type of question (different game level). In Figure 2 for instance, number 4 was selected for tracking the activity of the student named «Αιμιλία Φ.».

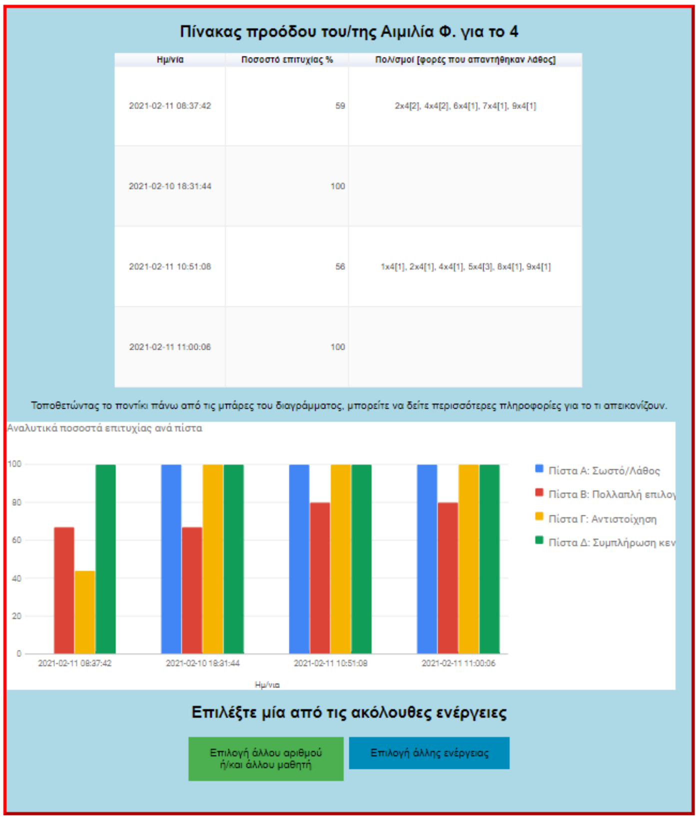


Figure 2. Individual student progress for a selected number.

In addition, the teacher can monitor the activity of all students on a specific date or time period (Figure 3).

Πρόοδος μαθητών του Γ1 στις 2021-02-04

Όνομα μαθητή	Ημ/νία	Επιλεγμένοι αριθμοί	Επιτυχία %	Μ.Ο. επιτυχίας τμήματος %
Ζωή Ν.	2021-02-04 15:53:05	3	88	79
		6	91	90
		9	94	79
Ηλίας Θ.	2021-02-04 15:55:14	3	81	79
		6	92	90
		9	79	79
Δημήτρης Φ.	2021-02-04 15:58:41	3	69	79
		6	88	90
		9	64	79

Οι γραμμές με κενό όνομα και ημερομηνία αντιστοιχούν στο ίδιο παιχνίδι του συγκεκριμένου μαθητή, όπου επέλεξε να παίξει με περισσότερους από έναν αριθμούς.

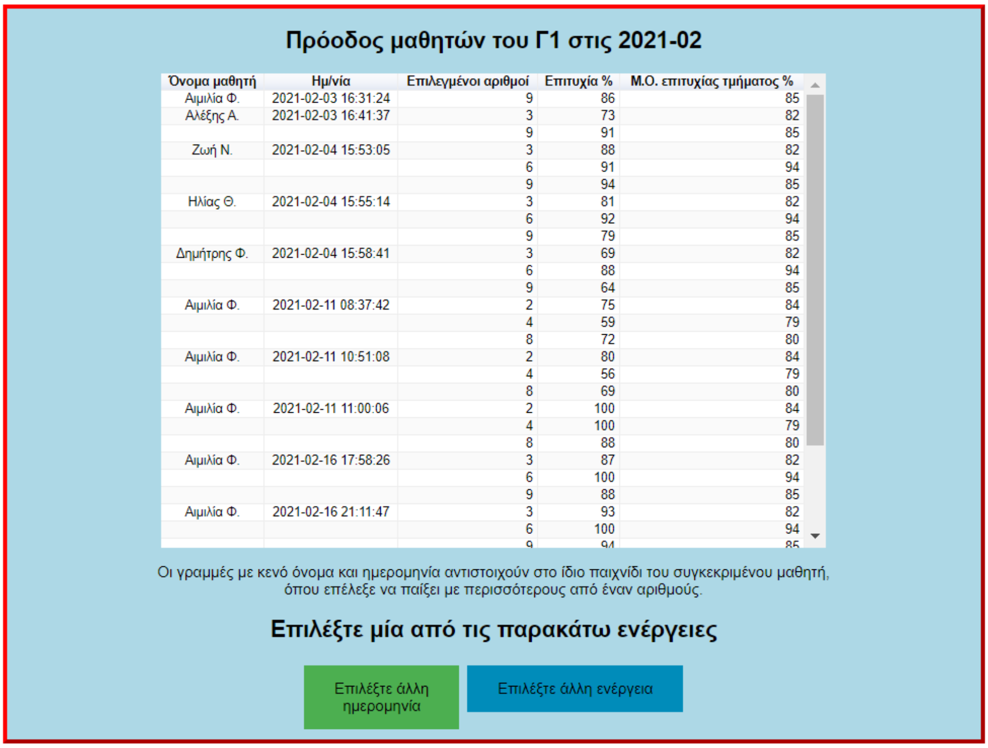
Επιλέξτε μία από τις παρακάτω ενέργειες

Επιλέξτε άλλη ημερομηνία

Επιλέξτε άλλη ενέργεια

Figure 3. Class progress on a selected date.

After selecting a specific date or a period of time (e.g., month), the teacher can see the students that played the game (Figure 4), their success rate for each number, and the summative success of all students on this particular multiplication number.



Πρόοδος μαθητών του Γ1 στις 2021-02

Όνομα μαθητή	Ημ/νία	Επιλεγμένοι αριθμοί	Επιτυχία %	Μ.Ο. επιτυχίας τμήματος %
Αιμιλία Φ.	2021-02-03 16:31:24	9	86	85
Αλέξης Α.	2021-02-03 16:41:37	3	73	82
		9	91	85
Ζωή Ν.	2021-02-04 15:53:05	3	88	82
		6	91	94
		9	94	85
Ηλίας Θ.	2021-02-04 15:55:14	3	81	82
		6	92	94
		9	79	85
Δημήτρης Φ.	2021-02-04 15:58:41	3	69	82
		6	88	94
		9	64	85
Αιμιλία Φ.	2021-02-11 08:37:42	2	75	84
		4	59	79
		8	72	80
Αιμιλία Φ.	2021-02-11 10:51:08	2	80	84
		4	56	79
		8	69	80
Αιμιλία Φ.	2021-02-11 11:00:06	2	100	84
		4	100	79
		8	88	80
Αιμιλία Φ.	2021-02-16 17:58:26	3	87	82
		6	100	94
		9	88	85
Αιμιλία Φ.	2021-02-16 21:11:47	3	93	82
		6	100	94
		9	94	85

Οι γραμμές με κενό όνομα και ημερομηνία αντιστοιχούν στο ίδιο παιχνίδι του συγκεκριμένου μαθητή, όπου επέλεξε να παίξει με περισσότερους από έναν αριθμούς.

Επιλέξτε μία από τις παρακάτω ενέργειες

Επιλέξτε άλλη ημερομηνία

Επιλέξτε άλλη ενέργεια

Figure 4. Class progress on a selected month.

7. Survey Methodology and Analysis

In the current study, we examined how this approach (i.e., the implemented MG and the dashboard recently incorporated) could facilitate the learning and teaching of multiplication skills. To reach teachers, a call for participation was sent through the official e-mail lists of primary schools. The 182 teachers that took part in the survey used the game (both the student view and the teacher dashboard) and were asked to fill in an anonymous online questionnaire with 37 questions and an optional comments field for general remarks about the game.

For the student view of the game, teachers were simply asked to play the game two to three times, make intentionally some mistakes, observe the score, see their progress per level, and see the progress of other students at the end of each game. For the teacher view, teachers were encouraged to explore the dashboard by connecting to a virtual test class with pre-assigned test students and readily available progress data. For additional support and to make sure that the teachers will try all major functionalities, a set of optional tasks were also provided: (1) See the progress record of student "Zoe N." for all multiplication tables she has selected. How many times did she answer 4×6 wrong? (2) Access the success rates for student "Aimilia F." for the multiplication table of number 4. Is 9×4 a multiplication she has answered wrong more than 3 times? Which type of questions seem to trouble her more?, and (3) See the activities of all your students on a specific date (4/2/21). Compare the score of student "Zoe N." with the average class score for the multiplication table of number 6.

This survey was conducted in order to investigate potential correlation between teachers' acceptance and positive attitude toward the notion of DGBL and their acceptance and perception about MG. Furthermore, it is very significant to have educators' opinion on the innovations MG shares with teachers, as they are given access to a dashboard that reveals detailed and summative aspects of their pupils' progress. More analytically, the purposes of the study included the following:

(a) To assess teachers' perceptions about MG's usefulness (MGU) in terms of perception/attitudes toward using digital games (ADG)
(b) To assess teacher's acceptance of MG (TA) and MG's usefulness (MGU) among to gender, age, and teaching experience
(c) To assess teacher's acceptance of MG (TA) in terms of barriers in using digital games (BD)
(d) To examine teacher's acceptance of using MG (TA) in the classroom in terms of teachers' attitude toward digital games (ADG)
(e) To investigate teachers' beliefs about the usefulness of MG in general (MGU)
(f) To investigate teachers' opinion about MG's interface (I)
(g) To investigate teachers' opinion about the OSLM characteristics of MG.

7.1. Method

7.1.1. Hypothesis Testing

Hypothesis 1 (H1). *Teacher's perception about MG's usefulness (MGU) is related to attitudes toward using digital games (ADG).*

Hypothesis 2 (H2). *Teacher's acceptance of MG (TA) and MG's usefulness (MGU) is related to gender, age, and teaching experience.*

Hypothesis 3 (H3). *Teacher's acceptance of using MG (TA) is related to perceived barriers in using digital games (BD).*

Hypothesis 4 (H4). *Teacher's acceptance of using MG (TA) is related to teacher's attitude toward digital games (ADG).*

More specifically, in order to examine teachers' beliefs about MG usefulness (MGU), two statements were given to be assessed on a 6-point Likert scale regarding how they consider the opportunity for students benefit in multiplication tables fluency when using MG, and MG's potential to support the traditional teaching process. Teachers' acceptance of MG (TA) was tested by asking them to assess on a 6-point Likert scale the likelihood of using MG systematically in their classroom and their intention of recommending MG to their students to use during their free time.

To examine teachers' attitude toward digital games (ADG), eleven statements were given to be assessed on a 6-point Likert scale regarding teachers' own attitude toward digital educational games, their own opinion on the usefulness of digital educational games in the teaching process, whether digital games can have a firm place in the educational practice, and if digital games are a strong current trend in education (and they expect that they will be used more widely in the near future). Regarding teachers' opinion on barriers (BD), statements with five significant barriers identified in the related literature (i.e., lack of time, technical problems, lack of educational curriculum flexibility, and lack of information about suitable and available digital games) were assessed in terms of their perceived significancy on a 6-point Likert scale.

7.1.2. Research Participants

The sample used in this research included primary education teachers in Greece from the general public education. Responses for analysis were collected by distributing the questionnaire online. Hence, we gathered a total of 182 responses.

7.1.3. Design of the Instrument

The questionnaire used in this study was composed of three sections. The first section records the demographics of participants including gender, age, teaching experience, and teacher's frequency of playing privately digital games. The second section refers to teachers' attitudes toward digital tools in their teaching, and the third section concerns MG's usefulness. The assessment tool contained 6 factors and 37 questions. Within them, factors represented by questions were created, aiming to assess the teachers' attitudes. Each subscale comprised 2–11 items. The score of each item ranged from 1 to 6 based on a 6-point Likert scale design. The last question (38th) was an optional open-ended one where respondents could fill in in free-form text any comment they had concerning MG.

7.1.4. Methodology

Cronbach's alpha was calculated to determine the instrument's internal consistency. As concerns hypothesis testing, mean scores for MGU, ADG, TA, and BD were used to establish association between the study variables. Comparisons of means of the construct's distribution TA and MGU was desired for gender, age, and experience groups. Due to the non-normality of the variables' nonparametric tests, Mann–Whitney test and Kruskal–Wallis test were carried out. Spearman's rho identified the associations between the teacher's acceptance of MG (TA) scores and teachers' attitude toward digital games (ADG), the teacher's acceptance of MG (TA) scores and barriers in using digital games (BD), as well as MG's usefulness (MGU) and attitudes toward using digital games (ADG).

7.1.5. Data Analysis

Out of 182 teachers, 159 (76.8%) were female, with the majority (96, 46.4%) in the age group of 30–45 years. The mean of teaching experience of the study was 15.4 ± 9.4 years. A total of 113 teachers (54.6%) work in urban schools, with 69 (34%) working in a provincial area (Figure 5 and Table 1).

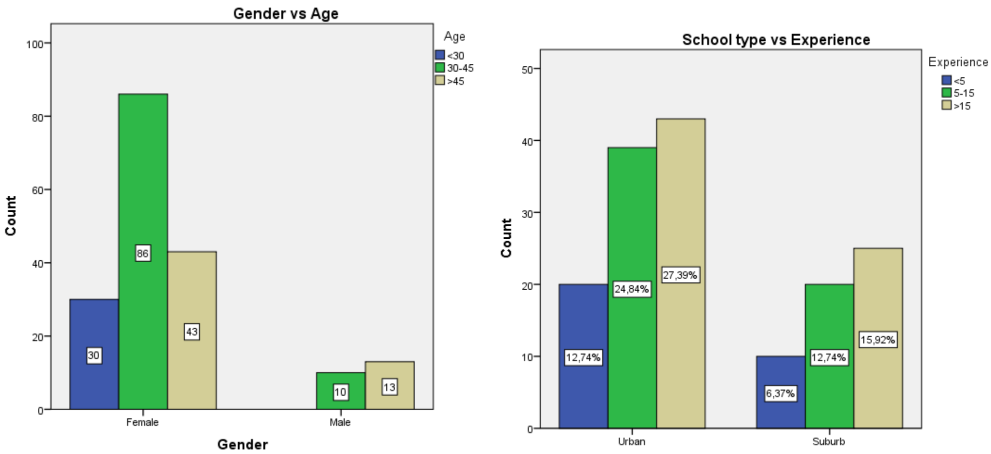


Figure 5. Demographics charts.

Table 1. Demographics of data.

Variables	N (%)
Gender	
Male	23 (11.1)
Female	159 (76.8)
Age	
<30	30 (14.5)
30–45	96 (46.4)
>45	56 (27.1)
Teaching Experience in years	
<5	34 (16.4)
5–15	67 (32.4)
>15	81 (39.1)
Teacher's playing hours	
>2 and ≥5	28 (13.5)
0	57 (27.5)
>0 and ≤2	89 (43)
>5	8 (3.9)
School area	
Urban	113 (54.6%)
Provincial	69 (33.3%)

Table 2 displays the mean scores for the key constructs, which are Teacher's attitude (perception) toward digital games (ADG)—3.97(0.672), Teacher perception about MG's usefulness (MGU)—5.32(0.78), Teachers' acceptance of MG (TA)—5.16(0.927), Barriers in digital games (BD)—4.52(1.066), Interface of MG (I)—5.10(0.759) and Social Opening of MG (SG)—5.07(0.890). Most of them present high mean scores (up to 5).

Table 2. Mean scores of variables.

Name of Variable (Acr.)	Min	Max	Mean Score	Std. Deviation
Teacher's attitude (perception) toward digital games (ADG)	2	5	3.97	0.672
Teacher perception about MG's usefulness (MGU)	2	6	5.32	0.784
Teachers' acceptance of MG (TA)	2	6	5.16	0.927
Barriers in d.g (BD)	2	6	4.52	1.066
Interface MG (I)	3	6	5.10	0.759
Social opening of MG (SG)	2	6	5.07	0.890

The constructs consist of several variables as depicted in Table 3, and a Cronbach test was used to assess their internal consistency. Cronbach's alpha values were higher than 0.7, which indicated the reliability of the proposed instrument.

Table 3. The construction of instrument.

Constructs-Items	Mean	Standard Deviation	Cronbach a
Barriers (BD)	4.52	1.066	0.764
V30	4.42	1.520	
V31	4.78	1.255	
V32	4.29	1.447	
V33	4.60	1.382	
V34	4.68	1.198	
MG Interface (I)	5.10	0.759	0.741
V36	5.04	0.891	
V37	5.15	0.879	
Social opening of MG (SG)	5.07	0.890	0.940
V39	5.02	1.022	
V40	5.02	1.040	
V41	4.98	1.005	
V42	5.14	0.935	
V43	5.18	0.947	
Teacher's Attitude (perception) toward digital games (ADG)	3.97	0.890	0.854
V14	4.94	0.953	
V15	5.03	0.895	
V16	5.15	0.937	
V17	2.71	1.291	
V19	4.55	1.250	
V21	3.92	1.336	
V22	4.96	1.179	
V23	4.63	1.158	
V24	3.68	1.468	
V25	4.19	1.249	
V26	4.08	1.311	
Teacher perception about MG's usefulness (MGU)	5.32	0.784	0.848
V34	5.27	0.814	
V35	5.38	0.869	
Teachers' acceptance of MG (TA)	5.16	0.927	0.828
V36	5.03	1.090	
V37	5.26	0.915	

7.1.6. Results of Hypothesis Testing

Spearman's rho correlation revealed that there is a significant correlation between MGU-ADG (r = 0.569, $p < 0.01$), TA-BD (r = 0.374, $p < 0.01$), and TA-ADG (r = 0.594, $p < 0.01$) (Table 4).

Table 4. Correlation between MGU, ADG, BD, and TA.

Variables (Hypothesis Testing)	Correlation Coefficient	** *p*-Value
MGU-ADG (H1)	0.569	0.0001
TA-BD (H3)	0.374	0.0001
TA-ADG (H4)	0.594	0.0001

** Correlation is significant at the 0.01 level (two-tailed).

As concerns H2 (Hypothesis 2), a Kruskal–Wallis test was conducted to examine the differences on TA and MGU according to the age groups and experience groups. No significant differences on TA ($\chi^2 = 1.907$, $p = 0.385$, df = 2) and MGU ($\chi^2 = 2.656$, $p = 0.265$, df = 2) were found among the three categories of age. Additionally, no significant differences on TA ($\chi^2 = 0.432$, $p = 0.806$, df = 2) and MGU ($\chi^2 = 0.263$, $p = 0.877$, df = 2) were found among the three categories of experience.

In addition, the Mann–Whitney U test showed that the distribution of TA (U = 1.454, $p = 0.1$) and MGU (U = 1.632, $p = 0.382$) is the same across categories of gender.

8. Discussion

This game of multiplication offers teachers the possibility to monitor the progress of their pupils. Specifically, the teacher can follow the progress of an individual pupil either for the overall activity or for a selected number. Through a properly configured dashboard, the teacher can keep track of pupil playing dates, the overall success rate, and the wrong multiplications as well as the frequency of each mistake. In the case of selecting a specific number, the teacher can see through the bar chart the student's success rates in each type of questions (which correspond to a different level in the game). Finally, the teacher can monitor the activity of all students on a specific date or time period (month). On a properly configured chart, the teacher can see which students were active at that time, each student's success rate on a training number (multiplication table), and the average success rate of all pupils in the classroom for a given number. The main purpose of this research was to investigate teachers' perception toward the MG in general and in relation to their attitude toward digital games. It was very important to find out teachers' willingness to use our tool and understand which are considered the main barriers that will possibly discourage them from utilizing the MG in their teaching process, as well as to reflect on their reactions regarding the social opening of the learner model supported by the MG.

According to the analysis of collected data in the previous section, the majority of respondents stated that it is very likely that they will use MG in the classroom and will recommend it to their students to use it at home as well, while they had a very positive opinion regarding the usefulness of the MG. More specifically, teachers stated that they strongly believe their students can benefit from using the MG and that it can significantly support them in their teaching.

Teachers rated positively the game interface usability and child-friendliness. The social opening of learner data to teachers was also assessed positively, as it allows them to plan more efficiently their teaching, making the appropriate adaptations to respond to individual pupil needs. Moreover, the fact that teachers can see the specific mistakes and their frequencies is considered as a very important feedback for improving their pupils' skills. Teachers also appreciated access to information about a pupil's progress on a selected number and the bar chart display of a pupil's progress in each game level (which reflects pupil scores for different question types in successive game plays).

Further statistical analysis revealed that teachers' positive attitude (perception) toward digital games leads to highly positive perception of MG's usefulness and to acceptance of the MG (H1 and H4). Furthermore, it was demonstrated that despite the severity teachers assign to barriers against using digital games, they are not becoming less willing to use MG in the classroom (H3). Finally, it is quite encouraging that teachers regardless of their gender, age, and teaching experience accept MG's educational value and usefulness (H2).

There were some quite interesting remarks made by teachers in the comments field of the questionnaire. Indicatively, there were remarks that a game such as the MG could greatly help students with attention deficit and other disorders, and that the game can help teachers save a lot of time they would typically spend examining each student in the classroom. In addition, some teachers stated that even though it is very important for the teacher to see details about the progress of each student, it is necessary to verify that it is the student alone that plays the game, and this cannot be guaranteed during off-school hours. This is a realistic issue and a limitation of the approach that can only be tackled if pupils play the game only at school, but this limits the opportunities for pupils to practice and improve their skills. It is a trade-off left to the teacher to decide and cannot be resolved by the game and the way it is implemented. In fact, it is a limitation faced by almost all remotely executed applications.

Another observation was that comparing the last pupil score with previous ones is a helpful indication of personal progress, but the social comparison (seeing the class average and the top scoring pupils) is not necessary and may discourage low-achieving pupils. Social comparison can be considered as a competition increase factor, which in turn is recognized as a strong motivation for improvement in educational settings [48,65,108–110]. The degree of competition and the details of implementing such features in the digital domain is a controversial subject. Our planned large-scale experiments with pupils will hopefully provide more insight on the topic from the pupils' standpoint.

Based on the feedback received by teachers and the analysis of collected data, teachers have positive views toward this approach for teaching multiplication and consider MG a useful learning tool from different points of view. Thus, there is strong evidence that MG could effectively support teaching and learning multiplication facts. This argument though needs to be verified and supported by large-scale experiments of the game with students and their teachers in the real-life setting of primary schools, which will be the next step of this effort.

9. Conclusions

The MG is a web-based assessment tool that supports pupils in acquiring and establishing multiplication facts skills. In the MG, learning and teaching goals are met, as it not only provides an engaging and motivating environment for pupils to play but also maintains a record of their activities in order to adapt to individual learner needs, to offer social comparison with peers, and to support informed decision making by the teachers. This paper describes the functional options offered to teachers by the MG dashboard and documents the outcomes of an online survey conducted with the participation of 182 primary school teachers. The purpose of the survey was to investigate teachers' attitude toward the benefits and support MG can provide to their teaching. To this end, the survey also recorded teachers' opinion on DGBL in general to allow for investigating potential correlation with their attitude toward MG.

According to existing bibliography [32,34,111], factors such as gender, age, and teaching experience influence teachers' beliefs about digital games. In our study, we found no evidence of gender, age, or teaching experience effect on teacher's acceptance of MG and their opinion about MG's usefulness. In addition, related bibliography [29,32,34,38,41,47,49,50,52] has identified many barriers that distract teachers from using digital games in the classroom. Evidence from the current study suggests that although teachers acknowledge the seriousness of four identified barriers, they did not affect their acceptance of MG. According to other researchers, factors such as the degree of relevance a digital game has to the educational context [34,41,44,51], its usefulness, and the learning opportunities it offers [37] can lead to adapting it in the educational process. Since MG satisfies these factors, it was expected and proved by the survey that MG is positively perceived by teachers. Furthermore, features such as students' support in knowledge acquisition [38,42,44,45,48], students' progress visualization [48], student rewarding, and entertainment [37] lead to the positive perception of a digital game. MG also possesses such characteristics, which contribute to its usefulness as perceived by teachers and their intention of using it.

The findings offer a promising basis for further exploration of the integration of game-based approaches to multiplication learning to promote active participation and interaction. These findings will be further investigated by planned extended studies that will involve a larger sample of participants comprising both teachers and pupils to lead to observations of learning effects and comparative analysis. As a next step, MG will be used a learning tool through several activities to study its effectiveness in the classroom with the participation of an adequately large number of pupils per grade of interest (second to fourth). The comparative testing of different MG versions (adaptive game, adaptive game with OLM features and adaptive game with OLM and OSLM features) is expected to reveal interesting findings in terms of learning outcomes, meta-cognition and motivation, and thus support teachers' positive opinion regarding the educational value of the MG as recorded in the presented study.

Author Contributions: Conceptualization, A.L. and M.R.; methodology, A.L.; software, A.L.; validation, A.L. and A.P.; evaluation of MG, A.L.; writing—original draft preparation, A.L.; writing—review and editing, M.R.; supervision, M.R. and J.G.; funding acquisition, A.L. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Hellenic Foundation for Research and Innovation (HFRI) under the HFRI PhD Fellowship grant number 267.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The questionnaire used for the survey is available (in Greek) at https://docs.google.com/forms/d/e/1FAIpQLSd3gYoK_c7wjGWz6j_K0lPWGKqOnVP36MGl7mt6cf5Zfsdamg/viewform?vc=0&c=0&w=1&flr=0&usp=mail_form_link (accessed on 18 March 2021) and the survey collected data can be acquired from https://docs.google.com/spreadsheets/d/1mS8nqKVW_2SuS617FDftxKStescnQuGTUcmS02sHFTM/edit?usp=sharing (accessed on 15 May 2021).

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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