UMARG

Using Mobile Augmented Reality Games to develop key competencies through learning about sustainable development

O4: Research study on MARG intervention

Transnational report

Elaborated by the University of Pitești

November 2021

Acknowledgement

UMARG is an Erasmus+ project funded by European Commission under Grant Agreement number 2019-1-RO01-KA201-063778

Project Reference: 2019-1-RO01-KA201-063778

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Introduction

This report was elaborated in the framework of UMARG project *"Using Mobile Augmented Reality Games to develop key competences through learning about sustainable development"* (ref. no. 2019-1-RO01-KA201-063778), a project financed by the European Commission through the Erasmus+ Programme. Detailed information about the project objectives and its results may be found on the project's website, at www.umarg.eu

The current report contains information and findings from one of the UMARG project main outcomes, namely the Intellectual Output 4 (IO4) titled *"Research study on MARG intervention"*. MARG intervention was a phase of the project that consisted in teaching with MARGs (MARGs - Mobile Augmented Reality Games) in several schools of each of the four participating countries - namely Romania (coordinator), Cyprus, Greece and the Netherlands - and then analysing change of teachers' attitude on MARGs and students' skill acquisition through MARGs. To that end, pre- and post-intervention questionnaires have been applied to teachers who taught with MARGs and to students who attended classes with MARGs.

This report thus presents the results of MARGs intervention. It is named IO4 Transnational Report. It has been compiled based on the national reports on IO4 intervention findings in Romania, Cyprus, Greece and the Netherlands. It consists of three parts:

Part 1 presents an outline of the basic information regarding the intervention in the four countries participating in UMARG project:

- names of the organisations involved in intervention;
- information about the participating teachers (MARGs implementers);
- information about the participating students;
- detailed intervention plan (dates of implementation of the games, games' names, classes involved, implementers) in each partner country.

Part 2 presents the results from the analysis of the data collected before, during and after the implementation phase. The results focus on:

- descriptive analysis of the teachers' attitudes towards MARGs before and after the implementation;
- qualitative analysis of teachers' answers regarding the whole process (difficulties, problems, strong and weak points, new ideas etc.);
- descriptive analysis of the pre- and post-intervention levels of students' skills that compose the targeted competences;
- descriptive analysis of student's acceptance of MARGs after the implementation.

Part 3 presents recommendations for policy makers, schools, teaching practice and further research.

Part 1: Basic information regarding the UMARG intervention

Partner country: ROMANIA				
No.	***Name of organisation***			***Organization's Acronym***
1	Universitatea din Pitești			UPIT
2	Școala Gimnazială "Mircea cel Btărân" Pitești			ScMcB
No.	***Class of students***	***Age of students*** *(in years)*	***Number of student-participants***	***Organization of the participants***
1	VI A	12-13	25	Școala Gimnazială *Traian* Pitești
2	VII A	13-14	24	Școala Gimnazială *Traian* Pitești
3	VI A	12-13	33	Colegiul Național *Ion C. Brătianu,* Pitești
4	VI B	12-13	28	Școala Gimnazială *Nicolae Iorga* Pitești
5	V B V G	11	28 29	Școala Gimnazială *Mircea cel Bătrân* Pitești
6	V C VI D	11 12	29 27	Școala Gimnazială *Mircea cel Bătrân* Pitești
7	VI A	12	28	Școala Gimnazială *Mircea cel Bătrân* Pitești
8	VI C	12	26	Școala Gimnazială *Mircea cel Bătrân* Pitești
		Total:	**277**	

Partner country: CYPRUS				
No.	***Name of organisation***			***Organization's Acronym***
1	Centre for the Advancement of Research & Development in Educational Technology			CARDET
2	Dimotiko Sxolio Apostolou Louka			DSAL
No.	***Class of students***	***Age of students*** *(in years)*	***Number of student-participants***	***Organization of the participants***
1	4th (D1)	10	15	Dimotiko Sxolio Apostolou Louka
2	4th (D2)	10	15	Dimotiko Sxolio Apostolou Louka
3	4th (D3)	10	18	Dimotiko Sxolio Apostolou Louka
4	5th (E1)	11	16	Dimotiko Sxolio Apostolou Louka
5	5th (E2)	11	17	Dimotiko Sxolio Apostolou Louka
6	5th (E3)	11	15	Dimotiko Sxolio Apostolou Louka
7	6th (ST'1)	12	18	Dimotiko Sxolio Apostolou Louka
8	6th (ST'2)	12	16	Dimotiko Sxolio Apostolou Louka
		Total:	**130**	

Partner country: GREECE				
No.	***Name of organisation***			***Organization's Acronym***
1	University of Aegean			UA
2	Ekpaideutiki Etaireia Rodou			EER
No.	***Class of students***	***Age of students*** *(in years)*	***Number of student-participants***	***Organization of the participants***
1	4th (D1)	10	13	Ekpaideutiki Etaireia Rodou
2	4th (D2)	10	11	Ekpaideutiki Etaireia Rodou
3	5th (E1)	11	12	Ekpaideutiki Etaireia Rodou
4	5th (E2)	11	11	Ekpaideutiki Etaireia Rodou
5	6th (F1)	12	15	Ekpaideutiki Etaireia Rodou
6	6th (F2)	12	14	Ekpaideutiki Etaireia Rodou
7	7th (A1)	13	13	Ekpaideutiki Etaireia Rodou
8	7th (A2)	13	12	Ekpaideutiki Etaireia Rodou
		Total:	**101**	

Partner country: NETHERLANDS				
No.	***Name of organisation***			***Organization's Acronym***
1				
2				
No.	***Class of students***	***Age of students*** *(in years)*	***Number of student-participants***	***Organization of the participants***
1	D1	14-15	20	Dr. Nassau College
2	D2	14-15	21	Dr. Nassau College
3	D3	14-15	20	Dr. Nassau College
4	D4	14-15	22	Dr. Nassau College
5	D5	12-13	20	Dr. Nassau College
6	D6	14-15	23	Dr. Nassau College
7	D7	14-15	22	Dr. Nassau College
8	D8	14-15	24	Dr. Nassau College
		Total:	**172**	

Intervention Plans

Partner country: ROMANIA					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
1	UPIT	VI A	Școala Gimnazială *Traian* Pitești (*Traian* Secondary School, Pitești)	E.T. and the Green Energy (E.T. și energia verde)	06.10.2021
				A journey through Europe: Discovering European Union's role (Uniunea Europeană)	06.10.2021
				Let's make our city sustainable (Orașe sustenabile)	08.10.2021
				Europe Day (Ziua Europei)	08.10.2021
				Staying Safe Online (Cyberbullying)	08.10.2021
2	UPIT	VII A	Școala Gimnazială *Traian* Pitești (*Traian* Secondary School, Pitești)	E.T. and Green Energy	04.10.2021
				Sustainable City	05.10.2021
				Europe Day	06.10.2021
				European Union	07.10.2021
				Cyberbullying	08.10.2021
3	UPIT	VI A	Colegiul Național *Ion C. Brătianu,* Pitești	Sustainable City	04.10.2021
				E.T. and Green Energy	04.10.2021
				Europe Day	05.10.2021
				European Union	05.10.2021
				Cyberbullying	06.10.2021
4	UPIT	VI B	Școala Gimnazială *Nicolae Iorga* Pitești (*Nicolae Iorga* Secondary School Pitesti)	Europe Day	21.09.2021
				E.T. and Green Energy	24.09.2021
				Sustainable City	28.09.2021
				European Union	1.10.2021
				Cyberbullying	5.10.2021
5	ScMcB	V B	Școala Gimnazială Mircea cel Bătrân, Pitești *(Mircea cel Bătrân* Secondary School Pitești)	ET and the green energy / ET si energia verde	06.10.2021
				Europe day / Ziua Europei	07.10.2021
				Sustainable cities / Orase sustenabile	11.10.2021
				European Union / Uniunea Europeana	12.10.2021

Partner country: ROMANIA					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
				Cyberbullying	17.11.2021
		V G	Școala Gimnazială Mircea cel Bătrân, Pitești *(Mircea cel Bătrân* Secondary School Pitești)	Mowgli / Mowgli	17.11.2021
				Endangered species / Specii pe cale de disparitie	18.11.2021
				In the park / Parcul lunca Argesului	22.11.2021
				The village museum / Muzeul Golesti	22.11.2021
				Colors of francophonie/ Ziua francofoniei	23.11.2021
6	ScMcB	VI C	Școala Gimnazială Mircea cel Bătrân, Pitești (*Mircea cel Bătrân* Secondary School Pitești)	ET and the green energy / ET si energia verde	18.10.2021
				Europe day / Ziua Europei	19.10.2021
				Sustainable cities / Orase sustenabile	20.10.2021
				European Union / Uniunea Europeana	21.10.2021
				Cyberbullying	18.11.2021
		V C	Școala Gimnazială Mircea cel Bătrân, Pitești (*Mircea cel Bătrân* Secondary School Pitești)	European Union / Uniunea Europeana	19.11.2021
				Cyberbullying	22.11.2021
				Endangered species / Specii pe cale de disparitie	23.11.2021
7	ScMcB	VI D	Școala Gimnazială Mircea cel Bătrân, Pitești (*Mircea cel Bătrân* Secondary School Pitești)	ET and the Green energy / ET si energia verde	18.10.2021
				Europe Day / Ziua Europei	19.10.2021
				Sustainable Cities / Orase Sustenabile	20.10.2021
				European Union / Uniunea Europeana	21.10.2021
				Cyberbullying	18.11.2021
		V C	Școala Gimnazială Mircea cel Bătrân, Pitești (*Mircea cel Bătrân* Secondary School Pitești)	ET and the Green Energy / ET si energia verde	19.11.2021
				Europe Day / Ziua Europei	22.11.2021
				Sustainable Cities / Orase Sustenabile	23.11.2021
8	ScMcB	VI A	Școala Gimnazială Mircea cel Bătrân, Pitești (*Mircea cel Bătrân* Secondary School Pitești)	ET and the Green energy / ET si energia verde	18.10.2021
				Europe Day / Ziua Europei	19.10.2021
				Sustainable Cities / Orase Sustenabile	20.10.2021
				European Union / Uniunea Europeana	21.10.2021
				Cyberbullying	18.11.2021
				Endangered Species / Specii pe cale de disparitie	19.11.2021

Partner country: ROMANIA					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
				In The Park / Parcul Lunca Argesului	22.11.2021
				The Village Museum / Muzeul Golesti	23.11.2021

Partner country: CYPRUS					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
1	CARDET	4th (D1)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	3/6/2021
				Art	3/6/2021
				Neighborhood solutions	3/6/2021
				World monuments	3/6/2021
				Women in Computer history	3/6/2021
2	CARDET	4th (D2)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	3/6/2021
				Art	3/6/2021
				Neighborhood solutions	3/6/2021
				World monuments	3/6/2021
				Women in Computer history	3/6/2021
3	CARDET	4th (D3)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	4/6/2021
				Art	4/6/2021
				Neighborhood solutions	4/6/2021
				World monuments	4/6/2021
				Women in Computer history	4/6/2021
4	CARDET	5th (E1)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	4/6/2021
				Art	4/6/2021
				Neighbourhood solutions	4/6/2021
				World monuments	4/6/2021
				Women in Computer history	4/6/2021

Partner country: CYPRUS					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
5	DSAL	5th (E2)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	7/6/2021
				Art	7/6/2021
				Neighbourhood solutions	7/6/2021
				World monuments	7/6/2021
				Women in Computer history	7/6/2021
6	DSAL	5th (E3)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	7/6/2021
				Art	7/6/2021
				Neighbourhood solutions	7/6/2021
				World monuments	7/6/2021
				Women in Computer history	7/6/2021
7	DSAL	6th (ST'1)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	11/9/2021
				Art	11/9/2021
				Neighbourhood solutions	11/9/2021
				World monuments	11/9/2021
				Women in Computer history	11/9/2021
8	DSAL	6th (ST'2)	Dimotiko Sxolio Apostolou Louka	Unlocking secrets	11/9/2021
				Art	11/9/2021
				Neighbourhood solutions	11/9/2021
				World monuments	11/9/2021
				Women in Computer history	11/9/2021

Partner country: GREECE					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
1	EER	4th (D1)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	10/05/21
				The mysterious extinction of Rhodes species [GR]	11/05/21

Partner country: GREECE					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
				ECO Aegean [GR]	12/05/21
				Building an ECO School [GR]	10/05/21
				The Quest of Colossus [GR]	13/05/21
2	EER	4th (D2)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	14/05/21
				The mysterious extinction of Rhodes species [GR]	17/05/21
				ECO Aegean [GR]	18/05/21
				Building an ECO School [GR]	17/05/21
				The Quest of Colossus [GR]	19/05/21
3	EER	5th (E1)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	20/05/21
				The mysterious extinction of Rhodes species [GR]	21/05/21
				ECO Aegean [GR]	24/05/21
				Building an ECO School [GR]	20/05/21
				The Quest of Colossus [GR]	25/05/21
4	EER	5th (E2)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	26/05/21
				The mysterious extinction of Rhodes species [GR]	27/05/21
				ECO Aegean [GR]	28/05/21
				Building an ECO School [GR]	26/05/21
				The Quest of Colossus [GR]	31/05/21
5	UA	6th (F1)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	20/09/21
				The mysterious extinction of Rhodes species [GR]	21/09/21
				ECO Aegean [GR]	22/09/21
				Building an ECO School [GR]	20/09/21
				The Quest of Colossus [GR]	23/09/21
6	UA	6th (F2)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	24/09/21
				The mysterious extinction of Rhodes species [GR]	27/09/21
				ECO Aegean [GR]	28/09/21
				Building an ECO School [GR]	24/09/21
				The Quest of Colossus [GR]	29/09/21

Partner country: GREECE					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
7	UA	7th (A1)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	30/09/21
				The mysterious extinction of Rhodes species [GR]	01/10/21
				ECO Aegean [GR]	04/10/21
				Building an ECO School [GR]	30/09/21
				The Quest of Colossus [GR]	05/10/21
8	UA	7th (A2)	Ekpaideutiki Etaireia Rodou	Diagoras Ideals [GR]	06/10/21
				The mysterious extinction of Rhodes species [GR]	07/10/21
				ECO Aegean [GR]	08/10/21
				Building an ECO School [GR]	06/10/21
				The Quest of Colossus [GR]	11/10/21

Partner country: NETHERLANDS					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
1	Dr. Nassau College	D1	Dr. Nassau College	Brazilië - gpwxapc	July 5 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
2	Dr. Nassau College	D2	Dr. Nassau College	Brazilië - gpwxapc	July 6 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
3	Dr. Nassau College	D3	Dr. Nassau College	Brazilië - gpwxapc	July 7 2021
				Water in Assen (gviwbpb)	

Partner country: NETHERLANDS					
No.	***Institution of the implementer***	***Class***	***Name of school***	***Name of MARG***	***Intervention date***
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
4	Dr. Nassau College	D4	Dr. Nassau College	Brazilië - gpwxapc	July 8 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
5	Dr. Nassau College	D5	Dr. Nassau College	Brazilië - gpwxapc	June 15 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
6	Dr. Nassau College	D6	Dr. Nassau College	Brazilië - gpwxapc	Sep 6 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
7	Dr. Nassau College	D7	Dr. Nassau College	Brazilië - gpwxapc	Sep 10 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	
8	Dr. Nassau College	D8	Dr. Nassau College	Brazilië - gpwxapc	Sep 13 2021
				Water in Assen (gviwbpb)	
				Energie transitie (goiiuzc)	
				Sustainable waste (ghtxcng)	
				Renew Go (getyyjs	

Part 2: Findings from analysis of collected data

2.1. Descriptive analysis of the teachers' attitudes towards MARGs before and after the implementation

We based the pre- and post-intervention questionnaires that we have applied to teachers on the questionnaires of Ibili et al. (2019).

For each question, we calculated the Mean Score (M) from all the participants' answers, as well as the Standard Deviation (SD). Then, we calculated the difference between the Mean Scores obtained for each question within the pre- and post-intervention questionnaire (Diff. in M). Interpretation and analysis of results was achieved based on the values of this difference (as well as of the Standard Deviation).

By focusing **on the Mean Score differences** of each category of questions, we may emphasize the following aspects, regarding:

Perceived Usefulness:

In all four countries, we found an increase in the Mean Scores of all the statements regarding the perceived usefulness of MARGs, which suggests that teachers consider them more useful after the intervention (the implementation of MARGs) than before. These results demonstrated that teachers were not convinced about the usefulness of MARG games before the intervention.

Perceived Ease of Use:

In all four countries, we found a high increase in the Mean Scores of all the statements regarding the Ease of Use of MARGs, which suggests that teachers consider them more easy-to-use and comprehensible tools after the implementation than before (in Cyprus the increase in the Mean Scores is much higher than in Romania, Greece and Netherlands).

Satisfaction:

Overall satisfaction has varied a lot across the four countries. Thus:

In Romania and Cyprus teachers are satisfied *with the performance of MARGs* while in Greece and Netherlands this satisfaction was slightly reduced after the implementation of the games.

In Romania and Netherlands teachers were pleased *with the experience of using MARGs*, while in Cyprus and Greece they weren't (in the latter countries this result is somehow contradictory with teachers' expressed satisfaction on MARGs performance; Greece found based on the qualitative data analysis, that factors such as i.e., technical problems, weather conditions have negatively affected teachers' experience).

However, teachers in Romania and Greece could not appreciate the wisdom of the decision to use MARGs as the Mean Score remained the same after implementation,

while teachers in Cyprus and Netherlands have seen their decision of using MARGs as a wise one (with higher positive difference between Mean Scores in Cyprus).

Anxiety:

In Romania, the (relatively) high positive differences between Mean Scores pre- and post-MARGs implementation obtained regarding anxiety to all questions, demonstrates that teachers are not yet comfortable with using MARGs. As resulted from the qualitative analysis, they need more training and more time to get used with the news approaches, the afferent applications and devices, as despite its benefits the use of MARGs is not yet a spread practice in Romanian school environment.

In Cyprus, we found an increase in the Mean Scores of the majority of the statements regarding the anxiety level while using MARGs with a decrease detected only in the Mean Score of one statement, which suggests that teachers do not afraid to experiment with MARGs but feel an overall anxiety about using them after the implementation than before.

In Greece and Netherlands, all Mean Scores related to the feeling of teachers' anxiety were reduced after the implementation phase. More specifically, teachers were less apprehensive when using MARGs, less hesitant to use MARGs and less afraid that they will make an unfixable mistake while using MARGs.

Attitude:

In Romania, teachers' attitudes towards the use of MARGs were slightly improved (the Mean Scores of 2 out of 3 related questions have increased post-implementation of MARGs, while one Mean Score difference was zero, showing neutrality thus no change of attitude regarding 'Using MARGs is a good idea'). This result supports the assumption that more time is needed to familiarize teachers with the use of MARGs in order to change more largely their attitude on MARGs.

In Cyprus and Greece, teachers' attitudes towards the use of MARGs were improved. Statistical analysis showed that the Mean Scores of all the related questions increased, which suggests that they are more positive in using MARGs after the implementation than before. Teachers considered the use of MARGs a good idea and liked their experience with them.

In Netherlands, teachers' attitudes towards the use of MARGs were not improved as statistical analysis showed that the Mean Scores of all the related questions decreased. This result is somehow inconsistent with teachers' satisfaction on using MARGs and their positive perception on MARGs ease of use.

Behavioural Intention:

In Romania, Cyprus and Netherlands we found an increase in the Mean Scores of all the statements regarding teacher's intention of using MARGs, which suggests that teachers are more willing to use MARGs in the future after the implementation than before. However, in the case of Romania this result seems contradictory with the one showing

that teachers are anxious with using MARGs; the explanation was found in the qualitative analysis, which revealed teachers' excitement in discovering this new technology and the high motivation and engagement they have seen in their students during MARGs implementation.

In Greece, despite their positive intentions, perceived ease of use and usefulness, data analysis showed no differentiation in the intention of teachers to use MARGs again. This result might be correlated with the slightly reduced satisfaction scores. Nevertheless, behavioural intention to use MARGs again in the future remained in high level pre- and post- the implementation phase.

Social Norms:

In Romania, the findings show that social norms influence teachers in relation to the use of MARGs and that overall, these influences are in favour of using MARGs.

In Cyprus, we found an increase in the Mean Scores of the majority of the statements regarding the level of influence from other people with a slight decrease in the Mean Score of one statement, which suggest that the teachers can be influenced by others' views.

In Greece, based on the descriptive analysis, we found that teachers believe that using MARGs is supported by people important to them and by people they value.

In Netherlands, the first item indicated decrease while the other two an increase. Overall, the findings indicate that teachers' intention to use MARGs are affected by social norms.

2.2. Qualitative analysis of teachers answers regarding the whole process (difficulties, problems, strong and weak points, new ideas)

We summarized below the main findings from the analysis of the open-ended questions of the post-intervention questionnaire.

What are the things that you liked in teaching with MARGs?

Romania: In teaching with MARGs teachers liked the increased enthusiasm, interest & engagement of their students. They also found that students remain motivated until the end of the lesson, retained the information more easily and enjoyed working/learning outdoors.

Cyprus: The teachers emphasized on students' productive interaction and how the MARG promoted communication and a collaborative environment among the groups. They also highlighted the fact that MARGs encouraged autonomous learning and their role was mainly limited to solving potential technical issues and drawing conclusions at the end of every scenario.

Greece: Most teachers pointed out that teaching outside classroom was a great experience. Students had the opportunity to learn *in-situ*, through inquiring-based

experiences. Furthermore, some teachers mentioned that learning with MARGs promoted collaboration and increased students' motivation and engagement in learning process.

Netherlands: Overall, the teachers found positive the fact that students could work outside of the classroom and had ownership over their learning through the use of the games. The games were perceived as a learner-centred approach.

Did you face any challenges regarding the use of MARGs in your teaching?

Romania: Teachers pointed out that the nature of their challenges while teaching with MARGs was only technical: sometimes low quality of the Internet connection, not so efficient performance of certain devices and/or application (GPS, TaleBlazer platform).

Cyprus: All the teachers addressed technical issues. Among others, teachers mentioned troubleshooting problems with the tablets and the Taleblazer application as well as how the sun was reflected on the tablet's screen making it harder to play the games during the realization of the outdoor activities. Also, one more challenge noted by most of the teachers was students' excitement and anticipation since such lessons go beyond typical education and disrupt the flow.

Greece: The majority of the teachers highlighted the importance of previous good classroom management in order to work with MARGs seamlessly. Furthermore, a significant number of teachers mentioned difficulties in teaching with MARGs due to technical issues (i.e. devices unable to connect with 4G network, GPS not responding accurately) as well as weather and environmental conditions (i.e. too much sun made it difficult for students to watch their mobile devices' screens, noisy background made it difficult to hear sound files).

Netherlands: Overall, the teachers did not report any main challenges other than minor technical.

What do you think can be improved regarding the use of MARGs in teaching?

Romania: Teachers who taught with MARGs appreciated that (more) training is needed to teachers in order to learn how to use MARGs and to reduce their reluctance on the use of MARGs; extending at national scale and at all levels the use of MARGs and increasing awareness by the help of decision makers, have been also recommended. However, one teacher opined that use of MARGs should be carefully weighted, through the perspective of reduced personal interaction.

Cyprus: Teachers agreed that the MARGs should be linked to the school curriculum in order the content to be relevant to the teaching material. Otherwise, the teachers will be unable to dedicate additional school hours to teach with MARGs. The teachers also commented on the improvement of the games developed in the context of the project as they would like more interactive features.

Greece: Teachers' proposals focused on improving classroom management, providing support for solving technical issues while playing and promoting personalized learning.

Netherlands: All teachers made a reference to the lack of availability of devices with mobile data connection to accommodate all students. They also suggested to have older students develop their own games as a way to motivate them and engage them.

Do you have any additional comments regarding your experience with MARGs as teaching tools?

Romania: Teachers' feedback on teaching with MARGs was a very positive one, they appreciated the experience of teaching with MARGs as a very positive one as shown by their comments from below (interesting, interactive, incredible, innovative) and the same was the perception of their students who showed interest and involvement.

Cyprus: The teachers believe that MARGs provide a better learning experience to students through the use of interactive and immersive elements. They also liked that the vast majority of the students were actively participating because of the MARGs. For instance, students that had lower academic performance or generally looking for ways to disrupt the lesson, showed particular interest in staying focused throughout the process. Overall, both teachers and students enjoyed the experience.

Netherlands: All teachers commented to the bad timing of the implementation of the materials. They felt that they had no choice to implement the materials in a different time frame due to the end date of the project. The implementation took place at a time were teachers experienced high workload and pandemic fatigue.

2.3. Descriptive analysis of the pre- and post-intervention levels of students' skills that compose the targeted competences

We processed the main results from the analysis of the data from the pre- and post-implementation questionnaires for students (Martins-Pacheco et al., 2020). In each question, we filled in the Mean Score (M) from all the participants' answers, as well as the Standard Deviation (SD). Lastly, we calculated the difference in the Mean Score between the pre and post questionnaire. By focusing **on the Mean Score differences** of each category of questions, we may emphasize the following aspects, regarding:

DIGITAL COMPETENCES

Problem solving:

In Romania, the decreases obtained in the means scores of all statements (although with small absolute values) indicate that through MARGs implementation students did not improve significantly their problem-solving skills.

In Cyprus, we found a slight decrease in the Mean Scores of the majority of the statements (q5=-0,15, q6=-0,02, q8=-0,15) regarding problem solving and a slight increase to some questions (q7=+0,02, q9=+0,09). The results suggest that students do not feel so confident in dealing with certain situations after the implementation than before.

In Greece, we found a small increase in the Mean Score in three out of five questions related to problem solving skills after the MARGs implementation. In the rest of the questions, data analysis showed no or little decrease. The results indicate that MARG may play a small but beneficial role in developing students' problem-solving skills.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their problem-solving skills.

Collaboration and Communication:

In Romania, for all statements the data analysis provided increases of the means scores (some very little, but anyway increased) which reflect the fact that MARGs positively impacted students' collaboration and communication skills.

In Cyprus, we found an increase in the Mean Scores of more than half of the statements (q11=+0,05, q12=+0,22, q14=+0,10, q16=+0,07, q17=+0,02) regarding collaboration and communication and a slight decrease to some questions (q10=-0,10, q13=-0,05, q15=-0,12, q18=-0,08). The results suggest that students feel somehow more confident about their communication and collaboration skills after the implementation than before.

In Greece, we found an increase in the Mean Score in eleven out of all questions related to collaboration and communication skills after the MARGs implementation. In the rest questions, data analysis showed no or little decrease. The results indicate that MARGs could be beneficial towards developing students' collaboration-communication skills.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their collaboration and communication skills.

Information and Data literacy:

In Romania, we found an increase in the Mean Scores for 4 out of 5 statements, which indicates that after using MARGs students became more confident in finding and managing information & data, except analysing their truthfulness.

In Cyprus, we found an increase in the Mean Scores of the majority of the statements (q23=+0,06, q24=+0,14, q25=+0,12, q26=+0,09 regarding data and information literacy and a slight decrease to one question (q27=-0,02). The results suggest that students feel more confident in finding and analysing information after the implementation than before even though they do not feel such confidence interpreting graphics and tables.

In Greece, we found a small increase in the Mean Score in four out of five questions related to this category of skills after the MARGs implementation. In the rest questions, data analysis showed little decrease. The results indicate that MARGs may play a small but beneficial role in developing students' data and information literacy skills.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their data and information literacy.

CIVIC COMPETENCES

Critical thinking:

In Romania, the 3 out of 4 increases in the means scores obtained, indicate that overall students have improved their critical thinking skills due to the MARGs that have been taught to them; this recommend MARGs as a good technology supporting the development of the critical thinking of students.

In Cyprus, we found an increase in the Mean Scores of the majority of the statements (q1=+0,09, q2=+0,15, q4=+0,16) regarding the axe critical thinking and a slight decrease to one question (q3=-0,17). The results suggest that students feel more confident at thinking critically towards an opinion after the implementation than before.

In Greece, we found a small increase in the Mean Score in three out of four questions related to critical thinking skills after the MARGs implementation. The results indicate that MARGs may play a beneficial role in developing students' critical thinking skills.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their critical thinking skills.

Respect for differences:

In Romania, the positive differences between Mean Scores pre- and post-implementation of MARGs (with only one negative exception), indicate that MARGs have had the potential to improve students' respect for differences.

In Cyprus, we found an increase in the Mean Scores of the majority of the statements (q28=+0,25, q30=+0,17, q31=+0,04, q32=+0,18, q33=+0,10, q34=+0,07) regarding the axe respect for differences and a slight decrease to one question (q29=-0,03). The results suggest that students feel more confident in communicating with other people and respecting their uniqueness after the implementation than before.

In Greece, we found an increase in the Mean Score in four out of all related questions after the MARGs implementation. In the rest questions, data analysis showed no or little decrease. The results indicate that MARGs may be beneficial towards helping students develop respect for differences.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their skills related to respect for differences.

Active citizenship:

In Romania, the positive differences between Mean Scores pre- and post-implementation of MARGs, show the students have improved their active citizenship skills and that MARGs have contributed to that.

In Cyprus, we found an increase in the Mean Scores of all the statements (q35=+0,01, q36=+0,09, q37=+0,17, q38=+0,04, q39=+0,04, q40=+0,27) regarding the axe active citizenship. The results suggest that students feel more confident in understanding their rights and responsibilities in both personal and social context after the implementation than before.

In Greece, we found a small increase in the Mean Score in three out of all related questions after the MARGs implementation. In the rest questions, data analysis showed little decrease. The results indicate that MARGs could prove beneficial for students towards developing active citizenship skills.

In Netherlands, the results indicate that MARGs did not impact students' perceived development of their active citizenship skills.

2.4. Descriptive analysis of student's acceptance of MARGs after the implementation

We processed the results from the analysis of the data from the pre/post implementation questionnaire for students (Balog & Costin, 2018). In each question, we filled in the Mean Score (M) from all the participants' answers, as well as the Standard Deviation (SD). The main findings of our analysis by focusing **on the Mean Score** of each category of questions are rendered below:

Perceived Ease of Learning:

In Romania, students perceived MARGs useful in supporting them to learn more easier and this conclusion is supported by the means scores that are close to value 4 (maximum value being 5); however, the deviation of answers is high.

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q1=4.18, q2=4.30, q3=4.33) which suggests that the majority support the statements that MARGs are useful and can improve their learning experience.

In Greece, all three questions regarding perceived ease of learning received high scores. Students found MARGs useful and able to improve their learning performance. Almost all students were able to learn and remember how to use MARGs.

In Netherlands, all three questions regarding perceived ease of learning received satisfactory scores. Students found MARGs useful and able to improve their learning performance.

Perceived Ease of Use:

In Romania**,** after attending classes taught with MARGs, students appreciated that MARGs are easy to use and admitted the ease of use of these games in learning about sustainable development. Again, the Mean Scores obtained are very good - 4 (even little above) out of 5 – and have led to this conclusion.

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q4=4.21, q5=4.25, q6=4.24) which suggests that the majority support the statements that MARGs were easy to use.

In Greece, all three questions regarding perceived ease of use received high scores. Students found MARGs easy to use as well as easy to use them as means to learn about sustainable development.

In Netherlands, all three questions regarding perceived ease of use received satisfactory scores. Students found MARGs easy to use as well as easy to use them as means to learn about sustainable development.

Perceived Efficiency:

In Romania, students appreciated MARGs as helpful to understand the lesson faster, learn more quickly and understand the lesson better, however the means scores obtained for efficiency were lower than the ones for ease of use (and the deviation of answers in this category, was the highest compared to the other categories).

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q7=4.14, q8=4.12, q9=4.10) which suggests that the majority support the statements that MARGs help them in better understanding the lesson.

In Greece, although perceived efficiency of MARGs was highly rated, data analysis showed a small decrease in the related questions (with mean scores 4,13, 4,12, 4,13 respectively) compared to other question categories. Students found that MARGs would help them to understand the lesson faster, understand the lesson better and learn more quickly. However, students' answers were highly deviated.

In Netherlands, all three questions regarding perceived efficiency received satisfactory scores. Students found that MARGs would help them to understand the lesson faster, understand the lesson better and learn more quickly.

Perceived Cognitive Absorption:

In Romania**,** students' perception on the cognition absorption is good (means scores around the value 4 out of 5 obtained for all questions in the category). However, students' answers were highly deviated.

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q10=4.25, q11=3.83, q12=4), which suggests that the majority support the statements that MARGs immersed them in the process.

In Greece, we found that while playing MARGs, time appeared to go by very quickly for most students. However, for many of them, MARGs made them absorbed and made concentration on the lesson difficult. This is also a well-documented disadvantage of MARGs in various others research studies.

In Netherlands, all three questions regarding perceived efficiency received satisfactory scores.

Perceived Enjoyment:

In Romania, students enjoyed using MARGs for learning and liked the experience (means scores obtained for this category - 4.01, 3.90 and 4.03 respectively - are higher than for other categories in general, although smaller than the means scores for the perceived ease of use, which is placed best in the entire questionnaire).

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q13=4.07, q14=4.19, q15=4.21), which suggests that the majority support the statements that using MARG was enjoyable.

In Greece, we found that students liked learning through MARGs and considered it an enjoyable learning experience. All three statements that fall into this category were above the average (mean scores q13=4.29, q14=4.34, q15=4,36 respectively), which suggests that students enjoyed using MARG.

In Netherlands, all questions regarding perceived enjoyment about the use of MARGs received satisfactory scores. Students enjoyed using MARGs and engaging in the activities.

Perceived Usefulness:

In Romania, students stated that MARGs are useful for them to improve and test knowledge and learn about sustainable development (Mean Scores around the value of 4 out of 5).

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q16=4.04, q17=4.18, q18=4.14), which suggests that the majority support the statements that MARGs were useful and improve their knowledge on Sustainable development.

In Greece, all three questions regarding perceived ease of learning received high scores. Students stated that after using MARGs their knowledge would improve, that exercises, and quizzes integrated in these games were useful to test their knowledge and lastly that these games helped them learn about sustainable development goals.

In Netherlands, all three questions regarding perceived ease of learning received satisfactory scores. Students stated that after using MARGs their knowledge would improve, that exercises, and quizzes integrated in these games were useful to test their knowledge and that the games helped them learn about sustainable development goals.

Intention to Use:

In Romania, students' intention to use MARGs is congruent with the results obtained to the previously questions - students enjoy MARGs, find them useful, easy to use, efficient – as the means scores in this category are close to value 4 (out of 5) showing a quite high intention of students to use MARGs in the future.

In Cyprus, we found that students rated all the statements that fall into this category great above the average (q19=4.26, q20=4.10, q21=4.21), which suggests that the majority support the statements that they are willing to use MARGs in their learning again.

In Greece, high scores in the above categories of the questionnaire consequently result in high scores in question related to intention to use MARGs. Students would like to use MARGs in the next future, in their school regularly as well as means for learning.

In Netherlands, all three questions regarding perceived ease of learning received satisfactory scores.

Part 3: RECOMMENDATIONS

Based on the results and findings from the research study on MARGs intervention, we could formulate the recommendations below, regarding the use of MARGs for key competences learning, at various levels, namely policy level, school level, teaching practice and further research.

3.1. POLICY LEVEL

As emphasized by the European Union's strategic policies and initiatives (such as EU Digital Strategy, Digital Skills and Jobs Coalition, Digital Innovation Hubs, Digital Education Action Aplan and many other similar) *"digital competences have become key for citizens to participate in today's social, economic and civic life".* Promoting citizenship, civic competence and the common values of freedom, tolerance and non-discrimination through education represent another central European pillar. In this context, more effort is necessary at educational level, to properly and efficiently prepare our children for the 21st century and for future challenges. Together, acquiring digital & civic skills can and should be utilised by school environment in promoting sustainable development. To this end, policy makers should ***reform school curriculum by including the use of Augmented Reality (AR) games and technologies*** as a valuable educational technology empowered solution. This would be in the same time a way to promote sustainable learning and education. Also, ***teachers' training on how to use Augmented Reality technologies should be considered while national educational policies are developed***, as researches showed the need for such training is real. Last but not least, ***sufficient funds to modernise education should be allocated in each country***, as in certain cases (e.g. Romania) national education is under-financed.

At a policy level, the government is the main policy maker that plays a catalyst role in the reformation of a country's education system. Therefore, they should employ strategies to incorporate and promote the use of Augmented or mixed reality in schools in the school curriculum. The establishment of a strong foundation aims to expand the potential of the technology in learning. In parallel, the government should invest in research to address the potentials and needs. For that reason, the government should turn to the people directly concerned; school leaders, educators and students that are often underrepresented in policy development. Their perspectives can provide valuable feedback to be utilised throughout the development phase. To move a step further, the government should adopt the Bring Your Own Device model (BYOD) that will allow personalised experiences to take place while meeting users' unique accessibility, privacy, and safety needs. In addition, students can install their own learning resources (e.g. e-textbook) and applications needed in their devices for their learning. At the same time, they should make sure that the necessary funds will be provided to cover any additional needs. Currently, a lot of schools are underequipped, a fact that affects the efficient implementation of new ideas and practices in the classroom. Another issue to be re-examined is the kind of support to be given at a school level. A holistic pedagogical framework as well as extensive guidelines and education are required to support the transitioning process.

Augmented Reality (AR) solutions can enhance classroom experiences and expand opportunities at all levels of learning. Governments should support further innovation by investing in research, skill-building, content development, and equitable adoption of immersive technologies. Resources and opportunities for educators to develop the skills and knowledge needed to successfully deploy Augmented Reality (AR) and Virtual Reality (VR) technologies should be provided, as well as development of resources and guidance to integrate AR/VR technologies into digital literacy initiatives to reduce the "learning curve" for students at all levels. There is also necessary to accelerate the development of quality, relevant, and age-appropriate immersive educational content by investing in government educational content for AR and expanding AR innovation in colleges and universities.

From a more practical perspective, Augmented Reality games provide an effective tool for distance learning, especially in situations when distance learning is the only option as well as in situations where the costs of field studies cannot be afforded. In this sense, Augmented Reality technologies have the potential to foster equity and inclusion by lifting up the barriers raised by physical distance and access to resources. Hence, we would argue that policy makers consider the possibility of incorporating such technologies in the curriculum for the purpose of promoting inclusivity goals.

3.2. SCHOOL LEVEL

As shown above, school curriculum should envisage acquisition of skills necessary for the 21st century, among which skills to use Augmented Reality technologies, because these foster deeper understanding of nature & reality and support students' critical thinking, problem-based learning and sustainable education. Schools should support teachers to acquire the necessary skills for using Augmented Reality Games in their teaching (through formal training but also through classroom practice) and to purchase equipment and devices required by implementation of such AR technologies.

Thus, at a school level, experts and experienced individuals or organisations in the field should develop a structured professional development course that will be accessible to school leaders and educators. The course should provide theoretical and practical knowledge regarding the use of Augmented Reality, tangible activities, implementation guidelines and examples of available platforms. In addition, a number of Augmented Reality games should be designed to be used as a reference point in the different subjects. Supporting educators, the frontline workers in education, may potentially increase their self-motivation and energy to employ new innovative pedagogical approaches in the classroom. Another important issue is the lack of proper equipment at schools. Therefore, the appropriate measures should be taken to equip schools with the necessary contemporary tools (e.g. tablets for all students). From their side, schools should conduct an initial analysis of the resources needed and share it among the policy makers. The students as the main interested party, should be also trained accordingly in order to be able to respond to the instructions and proceed as required. By exposing them in mixed reality environments, they will slowly

become part of their daily school routine and the facilitation of learning will become easier. Further, the school community should encourage participation in relevant actions and connect with other groups to exchange ideas and good practices.

Schools are encouraged to support the adoption of AR technology and invest in relevant equipment and software. Teachers should be supported with professional development courses and technical support in order to develop AR educational content. Bringing your Own Device (BYOD) could prove a cost-effective solution for school with low budget instead of purchasing new equipment.

Also, at the school level, it would be important to make MARGs as part of the curriculum because they are time-consuming, which are perceived as a barrier to meeting the demands of a heavy curriculum. A recognition system for teachers implementing innovative curriculum materials would also be helpful.

3.3. TEACHING PRACTICE

Teaching by using the Augmented Reality Games should be made known at a wider level within the school environment, presented and more largely applied in integrated sciences and/or various disciplines, in urban schools as well in remote or isolated schools and should become a daily practice for all teachers and students. Once the teachers discover AR technologies potential and benefits for learning and the students see their attractivity, AR games could do teaching and learning more motivational and performant.

Educational scenarios with the use of AR should be prepared and disseminated to educators as good practices. National curricula and textbooks should be designed in order to support activities with the use of AR. AR laboratories could be a safe alternative for experimentations in schools. AR could be intergraded in flipped classroom activities or online lessons.

Similarly to the school level, a recognition system would motivate teachers implement these materials. Practically, the availability of devices currently remains a problem.

3.4. FURTHER RESEARCH

Existing studies and research on the use of Augmented Reality technologies in education and learning must be completed with new ones that to bring updated information on students' and teachers' perception on AR games and technologies, impact of AR on learning performance, potential drawbacks, and necessary prerequisites and affordances which could make AR-based learning highly efficient. An interesting focus could be on how to assure required technical equipment and devices at classroom, school and educational system level and the exploration of bring-your-own-device (BYOD) as viable solution. New studies should also be interested in identifying specific skills of teachers for teaching with AR application and potentially negative effects at students' level. Comparative research between experimental groups to which intervention with AR technologies is applied and control groups in

which the teaching-learning process continues as usual, would bring more relevant results.

Also, at a research level, more research is required regarding the long-term efficacy of the mixed reality environments not only on students' engagement and interest but also on their academic performance. The research that can provide such critical information, can support educators in understanding the importance of integrating augmented reality in the lesson and the perceived benefits. Also, the different research case studies may establish new techniques and methodologies in the classroom (e.g. Problem-Based Learning). The research can identify strengths, weaknesses and challenges when using mixed reality environments with students that allows space for improvement; both on the technical and pedagogical aspects. With that being said, the industry will be able to proceed to a variety of adjustments as well as the design of new tools and on the other hand, policy makers and schools will be given the opportunity to experiment and probably at the end adopt new approaches.

Investment should be made in research for best practices to mitigate health and safety concerns for young children, and providing guidance on age-appropriate use. Research should focus on the development and validation of educational research tools that are adapted to AR technology.

These findings of this research are limited by the small sample size which did not allow an experimental design with the inclusion of a control and experimental group. However, the findings show that the use of Augmented Reality games has the potential to foster the development of 21st century skills. Therefore, we would recommend further studies replicating this preliminary study with a larger sample size with an experimental design for the purpose of obtaining more generalizable results.

Another limitation of the current study is associated with the novelty effect given that Augmented Reality applications are not currently widely utilized in school education. Hence, future studies should extent the duration of the Augmented Reality experience within a series of courses and carry out longitudinal investigations for the purpose of controlling for the novelty effect.

For future research purposes, we propose the adoption of ethnographic and discourse research methodologies that pay attention to the details of the social interactions and conversations that take place among students when using UMARGs for the purpose of providing detailed characterizations of their dialogues and learning processes, which go well beyond merely descriptive data that questionnaires provide.

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