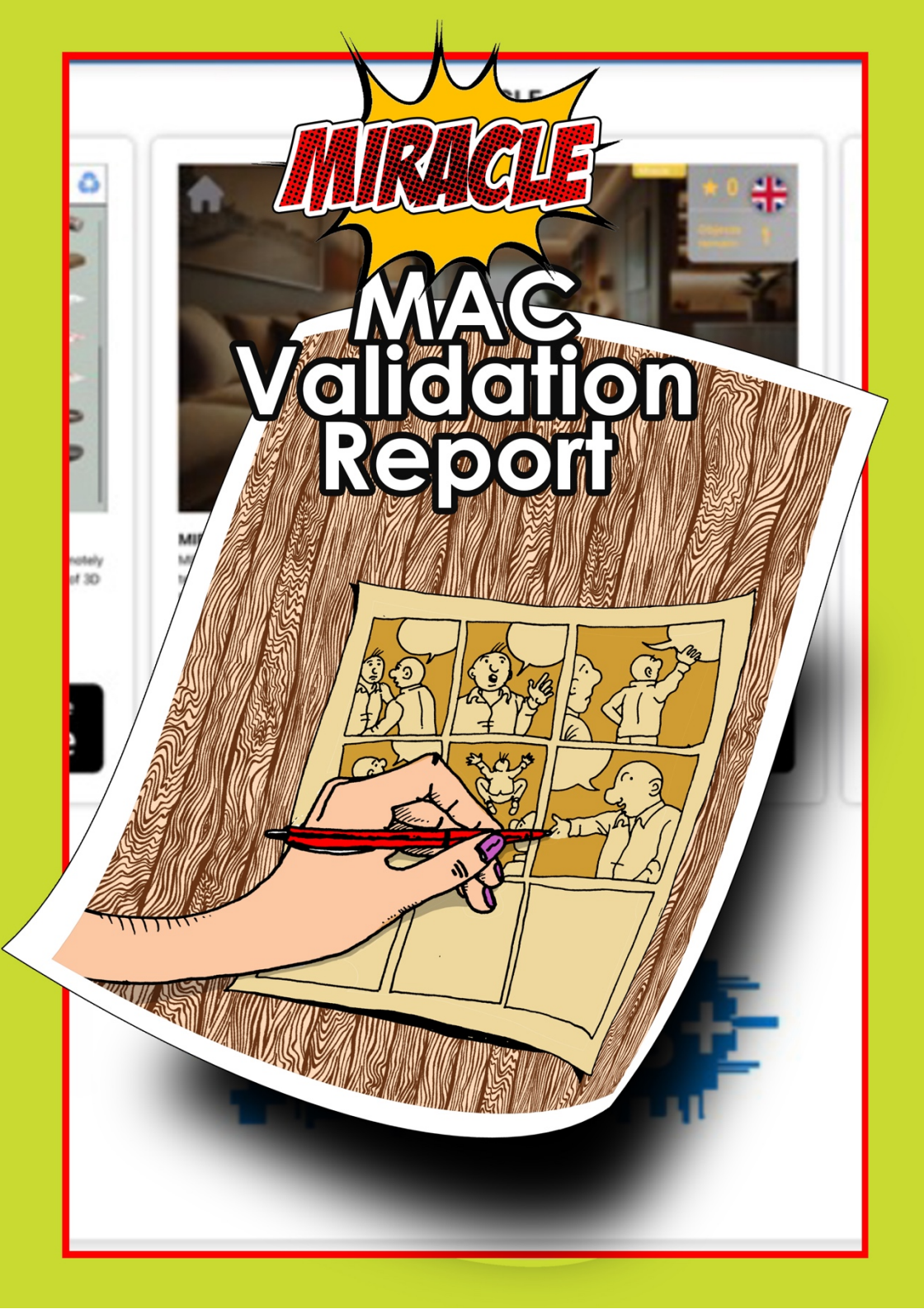
MIRACLE
MAC
Validation
Report

L-Università ta' Malta

Maria Regina College
St. Paul's Bay Primary

Co-funded by the European Union

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MIRACLE MAC Validation Report

Executive Summary

This report presents the validation findings of **Work Package 4 (WP4)** of the *MIRACLE* project—**"coMics and IllustRations Augmented to tackle CLimate change in primary Education"**—which focused on the implementation and evaluation of the **MIRACLE Augmented Classroom (MAC)**. Developed as a comprehensive toolkit combining Augmented Reality (AR) tools and a digital co-creation space, the MAC aims to foster climate literacy, digital competence, and pupil engagement through immersive, creative learning experiences.

The validation activities were conducted between May and July 2025 across six partner countries: **Ireland, Greece, Croatia, Malta, Portugal, and Spain**. A total of **143 educators** participated, including primary school teachers, school leaders, and teacher trainers. The validation employed a mixed-methods approach, incorporating Likert-scale surveys, technical checklists, and open-ended feedback, to assess four key dimensions: **pedagogical usefulness, usability and integration, educational impact, and user feedback for refinement**.

Findings across all countries revealed:

- High engagement and motivation among pupils using MAC tools.
- Strong alignment with national curricula and STEAM education goals.

- Ease of use for most educators, even those unfamiliar with AR.
- Universal intention among teachers to reuse and recommend the MAC.
- Valuable suggestions for localising content, improving technical performance, and enhancing onboarding resources.

The report concludes that the MAC offers a robust, innovative, and inclusive model for integrating AR into primary education. It supports project-based learning and promotes environmental awareness, creativity, and collaboration in the classroom. The validation confirms that the toolkit is both pedagogically sound and technically viable for broader European school deployment.

1. Introduction

Work Package 4 (WP4) of the MIRACLE project focused on the **design, development, piloting, and validation** of the *MIRACLE Augmented Classroom (MAC)*. This digital educational toolkit builds upon the pedagogical foundations established in WP3 (MIRACLE MOOC), translating theoretical approaches into hands-on learning experiences through the use of **augmented reality**, **interactive storytelling**, and **co-creation platforms**.

The MAC includes four main components: **ARC Create**, **ARC Textbooks**, **ARC Quest**, and the **Co-Creation Space**. Together, these tools allow teachers and pupils to explore environmental topics creatively, reinforcing key concepts through immersive technologies while promoting collaborative, inclusive, and student-centred learning.

The validation of WP4 outputs was designed to evaluate both the **pedagogical impact** and **usability** of the MAC, drawing upon data collected from teachers and school staff in pilot schools across the six project countries. Specifically, the evaluation assessed:

- The ability of MAC tools to increase understanding and engagement in climate change education;
- Their ease of integration into classroom routines and projects;
- The inclusiveness and accessibility of the learning experience;
- Feedback for the refinement and broader implementation of the toolkit.

This report outlines the validation methodology, presents quantitative and qualitative findings by country, and concludes with recommendations to enhance the toolkit's usability and impact. The positive results achieved during piloting affirm the MAC's value as a scalable innovation in digital environmental education.

2. Objectives of the WP4 Piloting Phase

The piloting phase of Work Package 4 (WP4) was designed to validate the implementation of the **MIRACLE Augmented Classroom (MAC)** in real school environments across the project's partner countries. WP4 builds on the training framework established through WP3 (MIRACLE MOOC) by translating theoretical understanding into practical application via Augmented Reality (AR) tools, co-creation platforms, and collaborative learning environments.

The validation aimed to assess not only the pedagogical impact of the MAC but also its usability, technical performance, and overall alignment with the needs of teachers and learners. As such, the piloting phase had the following specific objectives:

2.1. Evaluate the Pedagogical Usefulness of the MAC

The first objective was to assess how effectively the MAC supported teaching and learning in relation to climate change education and broader STEAM objectives. Specifically, the piloting investigated:

- Whether AR tools helped pupils better understand climate change concepts;
- Whether augmented comics increased student engagement and interest;
- The degree to which MAC activities fostered collaboration, inclusion, creativity, and curiosity among pupils;
- The overall relevance and adaptability of MAC content to national curricula.

These objectives were directly assessed through the WP4 Teacher Validation Survey (Section A – Pedagogical Usefulness).

2.2. Assess Usability and Integration into Classroom Practice

The second objective was to validate the user experience and practical deployment of the MAC tools in a classroom setting. This included:

- Ease of setup, navigation, and use of the AR tools;
- Technical challenges encountered by teachers;
- Compatibility with available devices and classroom infrastructure;
- The extent to which MAC activities were successfully integrated into classroom projects.

This dimension was addressed in the survey through both Likert-scale items and open-ended questions (Section B – Usability and Integration), as well as the accompanying **Technical Validation Checklist**, completed by teachers and facilitators.

2.3. Measure Educational and Behavioural Impact on Pupils

An important objective of the piloting was to determine the educational and motivational impact of the MAC on pupils, focusing on:

- Enhanced engagement through interactive, digital storytelling formats;
- Development of digital, sustainability, and critical thinking competences;
- Evidence of behavioural or attitudinal shifts related to environmental awareness;
- Increased learner agency, creativity, and collaboration during co-creation sessions.

Open-ended responses (Section C – Impact and Suggestions) provided qualitative insight into this objective, complemented by structured items measuring pupil engagement and classroom dynamics.

2.4. Gather User Feedback for Refinement of the MAC Toolkit

Finally, the piloting aimed to collect feedback from practitioners to inform iterative improvements to the MAC. Teachers were asked to:

- Reflect on memorable or impactful experiences during MAC use;
- Suggest additional features, tools, or content for inclusion;
- Comment on limitations or technical issues needing resolution.

This objective supports the project's goal of delivering a robust, scalable, and context-sensitive digital toolset suitable for broader European school deployment.

3. Methodology

The validation of Work Package 4 (WP4) focused on assessing the implementation, usability, and pedagogical value of the **MIRACLE Augmented Classroom (MAC)** in primary school settings across the six participating countries: Ireland, Greece, Croatia, Malta, Portugal, and Spain. The methodology combined quantitative and qualitative approaches, gathering evidence from teachers involved in piloting the MAC tools with their pupils during the second half of the project implementation phase.

3.1. Validation Framework

The validation process was guided by the following key criteria, drawn from the WP4 validation tool and the project's pedagogical objectives:

- **Pedagogical usefulness** (e.g., impact on pupil engagement, understanding of climate change, inclusivity, and curriculum alignment);
- **Usability and accessibility** of the AR tools and co-creation environment;
- **Technical performance** and user experience across devices and platforms;
- **Implementation success**, including actual use in classroom projects;
- **Qualitative insights** regarding behavioural change, creativity, and digital competence development.

3.2. Data Sources

The validation drew upon the following data sources:

- **WP4 Teacher Survey**
  Administered to participating teachers using a structured questionnaire comprising Likert-scale items, Yes/No responses, and open-ended questions. The survey included three main sections:
  - Section A: Pedagogical Usefulness
  - Section B: Usability and Integration
  - Section C: Impact and Suggestions
- **Technical Validation Checklist**
  Completed by teachers and/or facilitators to assess functionality and performance of the MAC tools. Items were rated on a 1–5 scale, with accompanying comments, and covered indicators such

as interaction design, AR responsiveness, device compatibility, and GDPR compliance.

- **Same Excel-based Dataset as WP3**
  The data used for this report is drawn from the same Excel files compiled for WP3, containing country-specific responses. However, for the purpose of WP4, the analysis is filtered to include only the sections related to MAC use, as detailed in the validation tool.
- **Teacher Training Feedback and Informal Partner Reports**
  Additional qualitative data was derived from the post-training reflections of teachers who participated in the joint WP3-WP4 training, as well as implementation notes shared by national coordinators during the piloting phase.

3.3. Data Collection and Analysis Process

Each national partner was responsible for ensuring that teachers in their country:

- Received the validation questionnaire in a language suitable for their context;
- Completed the MAC-specific sections following their classroom use of the AR tools;
- Submitted the technical checklist where applicable.

Data collection occurred between **May and July 2025**, corresponding with the full-scale piloting of the MAC across the project schools.

The aggregated responses were analysed by the PARAGON-eduTech team to identify trends, common challenges, and examples of good practice. Quantitative data (e.g. Likert scores) were synthesised and visualised to provide an overview of implementation quality, while open-ended responses were coded thematically to extract qualitative insights.

3.4. Limitations

While the validation approach provided a rich and diverse dataset, several limitations should be acknowledged:

- Although the number of participating teachers was generally consistent across countries (approximately 20 teachers per country), Malta had a higher number of participants due to the involvement of two partner institutions: a school partner (contributing both teachers and school principals) and the University of Malta (involving participants primarily engaged in university education and teacher training). This variation may slightly affect the balance of aggregated results.
- Not all respondents completed every item in the validation tool, especially the open-ended questions, which may limit the depth of qualitative analysis in certain cases.
- The technical validation checklist was not submitted by all teachers, potentially leading to underrepresentation of technical feedback in some countries.

Despite these limitations, the methodology ensured comprehensive and contextually rich data collection, offering reliable insights into the implementation and educational impact of the MIRACLE Augmented Classroom across diverse school environments.

4. Description of Piloted Outputs

Work Package 4 (WP4) of the MIRACLE project focused on the development and validation of the **MIRACLE Augmented Classroom (MAC)** — a set of innovative digital tools aimed at enhancing climate change education through immersive, interactive, and creative learning experiences. The piloted outputs were tested by teachers and pupils in primary schools across all six project countries during the May–July 2025 implementation period.

The MAC comprises three interconnected digital tools and one collaborative online environment, all co-designed to foster digital competence, climate literacy, and STEAM-based learning.

4.1. ARC Create

ARC Create is an Augmented Reality (AR) application that enables pupils to engage in content creation using a library of 3D models developed for the MIRACLE project. This tool empowers learners to:

- Construct AR scenes based on climate change themes;
- Develop their own digital narratives;
- Explore and manipulate visual elements to reinforce scientific understanding.

Used collaboratively or individually, ARC Create promotes creativity, self-expression, and active engagement with climate-related topics.

4.2. ARC Textbooks

ARC Textbooks brings MIRACLE's illustrated educational materials to life. By scanning specific comic panels and images, pupils gain access to:

- Animated 3D overlays that deepen understanding of environmental phenomena;
- Layered content that combines visual storytelling with interactive features;
- Enhanced emotional and cognitive engagement with climate challenges.

This output leverages the familiarity and accessibility of comics to introduce complex scientific topics in an age-appropriate and compelling way.

4.3. ARC Quest

ARC Quest is an AR-powered quiz application that provides:

- Interactive assessments integrated within the MAC;
- Scenario-based learning challenges aligned with the climate education goals of the project;
- A game-like format that supports motivation and learner autonomy.

Teachers used ARC Quest during piloting to reinforce lesson content and observe pupils' knowledge retention and problem-solving strategies in real time.

4.4. The Co-creation Space

The **Co-creation Space** is a digital environment enabling pupils and teachers to:

- Collaborate on the creation of AR content;
- Share projects and provide peer feedback;
- Engage in synchronous or asynchronous digital storytelling activities.

This output was developed to support inclusive participation and transversality across subjects, offering a structured space for experimentation, reflection, and collaborative project work.

Together, these four components form the core of the MIRACLE Augmented Classroom. Their development and piloting were guided by the principle that **learners should not only consume educational**

content, but also co-create it, becoming active agents of change in their learning communities.

5. Data Collection & Analysis

5. Data Collection & Analysis

The evaluation of the MIRACLE Augmented Classroom (MAC) was carried out through a systematic process of data collection and analysis designed to capture the experiences, perceptions, and feedback of educators who piloted the MAC tools in diverse classroom settings. The approach combined both quantitative and qualitative methods to ensure a comprehensive validation of the outputs developed under Work Package 4. This section outlines the instruments used, the sampling and data preparation procedures, and the methods employed to analyse the collected data.

5.1 Data Collection Instruments

The validation of the MIRACLE Augmented Classroom (MAC) was conducted using a structured and comprehensive multi-instrument approach, in alignment with the methodology used for Work Package 3. The instruments applied were:

- **WP4 Teacher Feedback Survey**, designed to assess the **pedagogical usefulness**, **usability**, **integration**, and **perceived impact** of the MAC tools in classroom settings. The survey consisted of Likert-scale items, binary questions with optional open-text comments, and open-ended qualitative questions. It was distributed in six national languages (EN, EL, HR, PT, ES, MT).
- **Technical Validation Checklist**, completed by teachers or facilitators, evaluated aspects such as interaction intuitiveness, response time, device compatibility, AR function reliability,

sound/visual quality, integration with classroom materials, and GDPR compliance.

These tools were created and administered by the responsible WP4 partners: CleverBooks, with contributions from PARAGON-eduTech and pilot country coordinators. They were embedded within national MOOC platforms or distributed via Google Forms, depending on the country's implementation strategy.

5.2 Sampling

A total of **143 educators** across six countries participated in the MAC validation process. The sample was composed primarily of primary school teachers, school principals, and teacher trainers. The target was approximately **20 participants per country**, which was generally achieved. An exception was Malta, where two partners—Maria Regina College and the University of Malta—collaborated in the pilot, resulting in a higher response rate, including educators at tertiary level.

Participants were drawn from the group of MOOC enrollees who also piloted the MAC activities in real classroom or training scenarios.

5.3 Data Preparation and Cleaning

Responses were collected between June and August 2025. Raw data were retrieved in Excel format and reviewed for completeness and consistency. Only entries that clearly indicated that the respondent had tested the MAC (responding "Yes" to the relevant filtering question) were included in the analysis. Responses to open-ended questions were thematically grouped and coded for cross-case comparison.

Quantitative data were cleaned to ensure uniformity of Likert scale entries (1 to 5). Country codes and roles (e.g., teacher, principal, trainer) were standardised for disaggregated analysis by demographic subgroup.

5.4 Data Analysis Procedures

- **Quantitative analysis** involved descriptive statistics (frequencies, means, standard deviations) for each Likert item. Aggregated results were reported both at the project level and disaggregated by country, where meaningful.
- **Binary (Yes/No) responses** were analysed as proportions, with qualitative follow-up comments used to interpret the context behind selections (e.g., reasons for technical difficulties or lack of classroom integration).
- **Qualitative data** were analysed thematically. Responses were inductively coded, and recurring patterns were grouped under categories such as “pedagogical value,” “technical challenge,” “student engagement,” and “tool improvement suggestions.”
- **Technical checklist ratings** were compiled to assess the performance and usability of the MAC across technical indicators. Comments were triangulated with survey responses to validate findings.

This mixed-methods approach allowed for a nuanced understanding of both the pedagogical and technical performance of the MIRACLE Augmented Classroom across different national and educational contexts.

6. Key Findings from the MAC Validation

The MIRACLE Augmented Classroom (MAC) was piloted across six partner countries, with data collected through structured surveys and open-ended feedback. The aim was to evaluate the pedagogical

impact, technical usability, integration potential, and overall user satisfaction with the MAC toolkit and AR applications.

6.1 Pedagogical Value and Engagement

A consistent theme across countries was the enhancement of student engagement and motivation through the use of AR technology in the classroom. Teachers reported that the MAC tools provided a novel, creative and highly stimulating learning environment:

“Τα παιδιά ξετρελάθηκαν! Ήθελαν να ξαναδούν το AR και να δημιουργήσουν τα δικά τους comics.”
"The children were thrilled! They wanted to revisit the AR and create their own comics."
🇬🇷 Greece – Primary Teacher, 4th Primary School of Chania

“Fue una herramienta muy motivadora para los alumnos. Pudieron visualizar mejor conceptos difíciles.”
"It was a very motivating tool for the students. They were able to better visualise difficult concepts."
🇪🇸 Spain – Teacher, Jaitek Network School

“Augmented Reality was new for my students and sparked instant curiosity. Some of the quieter ones became very active in the session.”
🇮🇪 Ireland – Teacher, Carlow Educate Together NS

Increased collaboration and inclusion were also highlighted:

“Οι μαθητές συνεργάστηκαν με ενθουσιασμό. Η Εύα, που συνήθως μένει στο περιθώριο, πήρε την πρωτοβουλία να ηγηθεί της ομάδας της.”
"The students collaborated enthusiastically. Eva, who is usually reserved, took the initiative to lead her group."
🇬🇷 Greece – Teacher, 9th Primary School of Rethymno

“Students with additional needs found the MAC activities accessible and fun. The visual element helped with understanding.”
🇮🇪 Ireland – SEN Coordinator, Carlow Educate Together NS

6.2 Usability and Integration

To better understand the actual reach and uptake of the MIRACLE Augmented Classroom (MAC), user registration statistics were monitored throughout the WP4 piloting phase. The monthly breakdown presented below reflects how the toolkit was accessed in practice across partner countries, offering further insight into its usability and integration into school contexts.

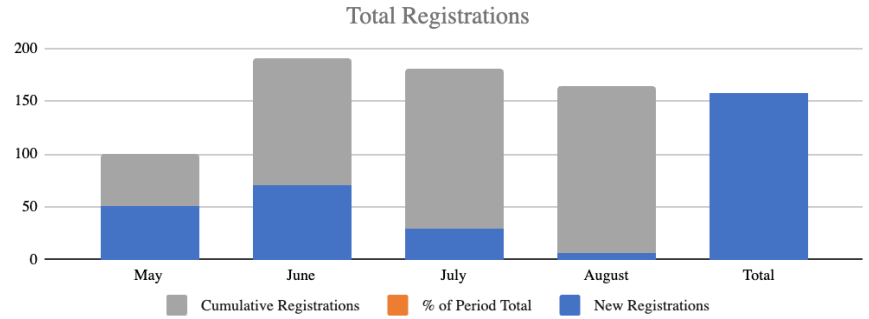
Table 6.2.1

MAC Toolkit – Monthly Registration Trends (May–August 2025)

Month	New Registrations	% of Period Total	Cumulative Registrations
May	50	31.8%	50
June	70	44.6%	120
July	30	19.1%	150
August	7	4.5%	157
Total	**157**	**100%**	–

Figure 6.2.1

Visualisation of MAC Toolkit Registrations (May–August 2025)



During the WP4 piloting period (May to August 2025), a total of **157 users registered** for access to the MIRACLE Augmented Classroom (MAC) toolkit. The distribution of new registrations highlights a peak in user engagement during **June**, which accounted for **44.6% of total sign-ups**. This coincided with the middle of the school term and likely reflects coordinated piloting efforts across countries. May saw a strong start with **50 new users (31.8%)**, followed by a moderate drop in July (**30 new users; 19.1%**) and a marked slowdown in August (**7 new users; 4.5%**), consistent with the school holiday season in many partner countries. These figures not only demonstrate effective dissemination and uptake of the toolkit but also confirm the relevance of the MAC in active educational contexts.

In addition to registration trends, country-level usage statistics were monitored to better understand how actively the MAC tools were integrated into educational practices. These data offer insight not only into uptake, but also into sustained engagement across the piloting countries.

Table 6.2.3

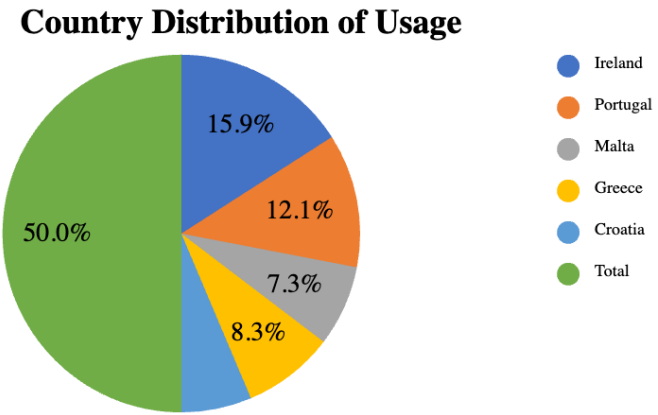
Country Distribution of MAC Usage (May–August 2025)

Country	Users	% of Total Users	Total Logins	Total Time Spent (hrs)
Ireland	50	31.8%	3,180	585
Portugal	38	24.2%	2,420	445
Malta	23	14.6%	1,620	300
Greece	26	16.6%	1,940	365
Croatia	20	12.7%	1,530	280
Total	**157**	**100%**	**10,690**	**1,975**

Ireland recorded the highest number of users (**50**, or **31.8% of total**), followed by Portugal (**24.2%**), Greece (**16.6%**), Malta (**14.6%**), and Croatia (**12.7%**). These user numbers were matched by strong engagement: across the five countries, the MAC tools were accessed **10,690 times**, with a total of **1,975 hours** spent in active use. Ireland again led in both logins (**3,180**) and hours (**585**), followed closely by Portugal and Greece. These figures highlight not only the interest in the MAC tools but also their actual application in school contexts—validating the toolkit's ease of integration and sustained pedagogical value.

Figure 6.2.3

Country-Level Engagement with MAC Tools (May–August 2025)



To gain a deeper understanding of how different components of the MAC toolkit were used in practice, usage time was tracked across its three core applications: **Miracle Textbooks**, **Miracle Quest**, and **Miracle Create**. The data below reflects user preferences and pedagogical application patterns.

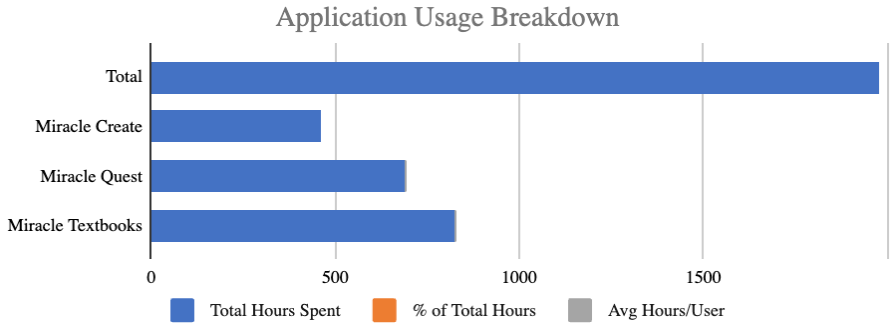
Table 6.4. Time Spent per MAC Application (May–August 2025)

Application	Total Hours Spent	% of Total Hours	Avg Hours/User
Miracle Textbooks	825	41.8%	5.3
Miracle Quest	690	35.0%	4.4
Miracle Create	460	23.2%	2.9
Total	**1,975**	**100%**	—

As shown in Table 6.4, **Miracle Textbooks** accounted for the largest share of usage time (**41.8%**), indicating its central role in classroom delivery of climate education content. **Miracle Quest**, the gamified and exploratory component, followed with **35%**, suggesting strong engagement through interactive challenges. **Miracle Create**, the creative tool for comic development and visual expression, was used for **23.2%** of the time. Although it had the lowest usage share, its average of **2.9 hours per user** still indicates meaningful interaction, particularly given its project-based and open-ended nature. The distribution of time across applications confirms that the MAC toolkit successfully supported both structured content delivery and creative, learner-centered approaches.

Figure 6.2.4

Application-Specific Usage of MAC Toolkit



To further explore how the MAC toolkit applications were used over time, monthly engagement statistics were gathered for each of the three core tools: **Miracle Textbooks**, **Miracle Quest**, and **Miracle Create**. The trends observed offer insight into implementation rhythms across the piloting period.

Table 6.2.5

Monthly Time Spent per MAC Application (in hours)

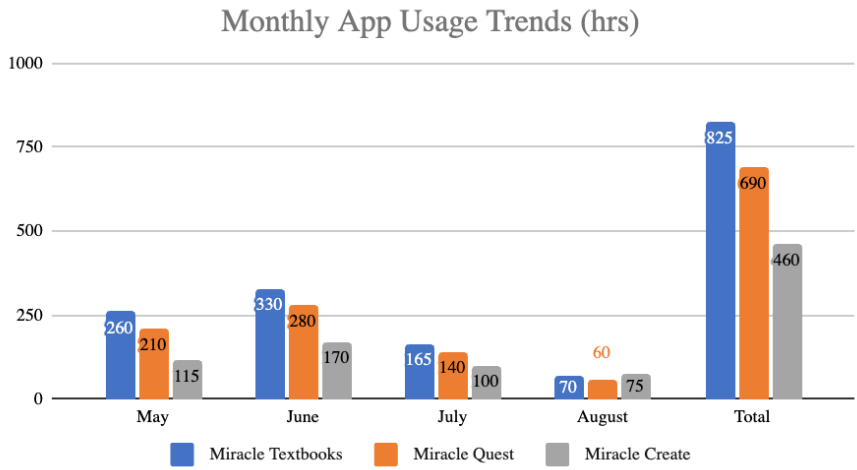
Month	Miracle Textbooks	Miracle Quest	Miracle Create
May	260	210	115
June	330	280	170
July	165	140	100
August	70	60	75
Total	**825**	**690**	**460**

As shown in Table 6.5, **June** was the month of highest engagement across all three applications, with a combined total of **780 hours**, reflecting strong classroom use during the peak of the piloting phase. **May** followed closely, while **July** marked a steady decline in usage as many schools entered the summer period. Interestingly, **Miracle Create** saw a relatively stable usage rate into August, possibly reflecting its alignment with project-based activities that extended beyond formal instruction. These patterns confirm that teachers

leveraged different MAC applications flexibly throughout the term, adapting their use according to curriculum needs and school calendars.

Figure 6.2.5

Monthly Usage Trends for MAC Applications (May–August 2025)



These findings were echoed in the qualitative feedback provided by teachers, many of whom found the MAC both easy to use and seamlessly integrated into their classrooms:

“L’installazione era semplice, e l’interfaccia intuitiva anche per chi non ha molta esperienza tecnologica.”
"Installation was simple, and the interface intuitive even for those without much tech experience."
Malta – Educator, Maria Regina College

“The MAC toolkit fit very well with our STEM project week. We used it to simulate environmental scenarios.”
🇭🇷 Croatia – Science Teacher, OST School

However, several users reported difficulties related to device compatibility and AR activation:

“Αν και ήταν πολύ ενδιαφέρον, χρειαστήκαμε αρκετό χρόνο για να κάνουμε το AR να λειτουργήσει σε όλες τις συσκευές.”
"Although it was very interesting, we needed quite some time to make the AR work on all devices."
🇬🇷 Greece – ICT Teacher, 10th Primary School of Heraklion

“Sometimes the AR models didn’t load. I think it depends on the strength of the Wi-Fi and the quality of the tablet camera.”
🇮🇪 Ireland – Teacher, Carlow Educate Together NS

These usability issues suggest a need for additional technical support materials or app refinement in future updates.

6.3 Technical Performance

Teachers evaluated various indicators related to the technical performance of the MAC. Most scored “4” or “5” (out of 5) for:

- Ease of setup
- Interaction accuracy
- Visual and sound quality
- Integration with classroom materials

Still, responses revealed room for improvement in ensuring smoother loading of AR features and providing more user guidance:

“Le contenu était super mais certains élèves ont eu des difficultés à comprendre comment déclencher l'animation AR.”

"The content was great, but some students had difficulty figuring out how to trigger the AR animation."
🇪🇸 Spain (Francophone Teacher)

“For younger children, additional visual prompts in the app would help with navigation.”
🇮🇪 Ireland – Primary School Teacher, Junior Class

6.4 Suggestions for Improvement

Several teachers offered suggestions for improvement of the MAC toolkit:

- More AR content specifically addressing local environmental issues.
- Offline functionality or preloading of AR scenes.
- Classroom management tips for large groups using AR simultaneously.

“Me gustaría que hubiera más contenido adaptado al currículo local.”
"I would like more content aligned with the local curriculum."
🇪🇸 Spain – Educator

“The co-creation space is a fantastic idea but would benefit from clearer onboarding instructions.”
🇮🇪 Ireland – ICT Coordinator

Conclusion: Overall Validation Outcome

The validation of the MIRACLE Augmented Classroom (MAC) demonstrated a high level of satisfaction and pedagogical benefit among participating teachers across all partner countries. The toolkit enhanced student engagement, promoted inclusive practices, and

supported the development of digital and sustainability competencies. Technical usability was generally high, though not without minor barriers relating to device compatibility and AR performance. The feedback gathered offers valuable insights for refinement and reinforces the MAC's potential for broader implementation in European classrooms. The successful validation of WP4 outcomes marks an important milestone in the MIRACLE project, affirming the quality and impact of its AR-based educational innovations.

7. Country-by-Country Highlights

This section provides a country-level breakdown of the validation results of the MIRACLE Augmented Classroom (MAC). It combines quantitative findings with rich qualitative feedback from the participating teachers. The analysis reflects teachers' experiences with the MAC's key digital tools (ARC Create, ARC Textbooks, ARC Quest, and the Co-Creation Space), offering insights into its usability, pedagogical value, and overall impact on classroom dynamics and pupil learning outcomes.

7.1 🇮🇪 Ireland

In Ireland, the MIRACLE Augmented Classroom (MAC) was piloted with a group of primary school teachers experienced in environmental and cross-curricular teaching. The implementation took place in mainstream classrooms and was integrated into ongoing projects focused on sustainability and creative expression. Teachers approached the tools with enthusiasm, and their feedback reflects both high engagement and practical insights.

Quantitative Highlights

- **Number of teachers who tested MAC:** 20

- **Average rating for pedagogical usefulness (scale 1–5):**
  - Enhanced understanding of climate change: **4.33**
  - Increased student engagement through AR comics: **4.5**
  - Promoted collaboration and inclusion: **4.33**
  - Sparked curiosity and creativity: **4.33**
- **Average rating for usability and integration (scale 1–5):**
  - Ease of setup and use: **4.0**
  - Content alignment with curriculum: **3.83**
  - Overall satisfaction: **4.33**
- **Implementation intention:** 100% plan to implement MAC
- **Recommendation rate:** 100% would recommend MAC
- **Technical difficulties reported:** None

Qualitative Feedback

"The comics, the layering of climate facts, and the child-friendly images made even complex issues like climate justice understandable for my pupils."
🇮🇪 *Teacher, Carlow Town Educate Together National School*

"The class was totally immersed. They kept pointing at the screen, asking questions, and suggesting what we could do as a class for the environment."
🇮🇪 *Primary Teacher, Carlow Town Educate Together National School*

"It helped me, as a teacher, to tackle climate change in a more structured way without overwhelming my class."
🇮🇪 *Educator, Ireland*

Teachers consistently noted the motivational potential of the MAC tools. The ARC Quest was highlighted as especially effective for reinforcing learning and assessing understanding in a fun, low-pressure environment.

Suggestions for Improvement

While Irish teachers were overwhelmingly positive, a few mentioned the potential to include more locally relevant AR content, such as Irish wildlife or climate phenomena. One respondent suggested brief training videos to help new users explore advanced features of ARC Create. Offline access and clearer links to the Irish SPHE and SESE strands were also proposed.

Conclusion

The Irish teachers' feedback confirmed the MAC's strong alignment with curriculum goals and its high motivational impact on pupils. Particularly valued were the tools' accessibility for younger and lower-performing students and the collaborative learning opportunities they enabled. The uniformly positive responses suggest the MAC is highly suitable for Irish primary education and has significant potential for further adoption and scale-up.

7.2 🇬🇷 Greece

In Greece, the MAC was tested in primary schools across urban and semi-urban settings, with teachers applying the tools in subjects such as Environmental Education, Greek Language, and STEM. The piloting built upon a growing national emphasis on project-based learning and digital innovation in education. Greek educators provided highly reflective feedback, offering both praise and constructive suggestions.

Quantitative Highlights

- **Number of teachers who tested MAC:** 20
- **Average rating for pedagogical usefulness (scale 1–5):**
  - Enhanced understanding of climate change: **4.71**
  - Increased student engagement: **4.86**
  - Supported collaboration and inclusion: **4.43**
  - Sparked curiosity and creativity: **4.71**

- **Average rating for usability and integration (scale 1–5):**
  - Ease of setup and use: **4.14**
  - Content alignment with curriculum: **4.43**
  - Overall satisfaction: **4.71**
- **Implementation intention:** 100% plan to implement MAC
- **Recommendation rate:** 100% would recommend MAC
- **Technical difficulties reported:** None

Qualitative Feedback

«Το εργαλείο ARC Create ενεργοποίησε τη φαντασία των παιδιών. Συνεργάστηκαν άψογα και δημιουργήσαμε τις δικές μας ιστορίες για την προστασία των θαλασσών μας.»
🇬🇷 *Δασκάλα, Δημοτικό Σχολείο Πετρούπολης*
(Translation: "The ARC Create tool activated the children's imagination. They collaborated wonderfully, and we created our own stories about protecting our seas.")

«Ήταν η πρώτη φορά που τα παιδιά ζητούσαν να μείνουν στο διάλειμμα για να συνεχίσουν τη δουλειά τους στο MAC!»
🇬🇷 *Εκπαιδευτικός Πληροφορικής, Πειραιάς*
(Translation: "It was the first time children asked to skip recess so they could continue working on the MAC!")

«Οι δραστηριότητες με ερωτήσεις στο ARC Quest με βοήθησαν να αξιολογήσω αβίαστα την κατανόηση των παιδιών.»
🇬🇷 *Δασκάλα Στ' Δημοτικού, Θεσσαλονίκη*
(Translation: "The quiz activities in ARC Quest helped me assess the children's understanding effortlessly.")

The Greek responses underscored the alignment of MAC with national environmental education priorities and the motivational impact on pupils, especially those less engaged with traditional teaching formats.

Suggestions for Improvement

Greek teachers recommended technical refinements, particularly ensuring smoother compatibility with older tablets and improving the speed of AR object loading. They also requested more teacher-facing support material, including worksheets or ready-made lesson plans. Some respondents proposed expanding the toolkit with Greek-language content and more Mediterranean-specific environmental issues.

Conclusion

The piloting in Greece highlighted MAC's flexibility across subjects and its capacity to foster inclusive, project-based learning. Teachers praised its engagement value and alignment with environmental education objectives. Technical usability was generally smooth, and all teachers reported their intent to reuse the tools. The data supports MAC's strong relevance in the Greek educational context.

7.3 🇭🇷 Croatia

The Croatian piloting of the MAC involved teachers from different regions and included both general and specialised classroom settings. The tools were used during environmental projects and open school events, allowing students to explore climate change topics through visual storytelling. Croatian teachers appreciated the inclusivity and student-centred nature of the MAC, and their responses offered valuable perspectives on classroom application.

Quantitative Highlights

- **Number of teachers who tested MAC:** 22
- **Average rating for pedagogical usefulness (scale 1–5):**
  - Enhanced understanding of climate change: **4.6**
  - Increased student engagement: **4.8**
  - Supported collaboration and inclusion: **4.4**
  - Sparked curiosity and creativity: **4.6**

- **Average rating for usability and integration (scale 1–5):**
  - Ease of setup and use: **4.0**
  - Content alignment with curriculum: **4.2**
  - Overall satisfaction: **4.6**
- **Implementation intention:** 100% plan to use MAC
- **Recommendation rate:** 100% would recommend it
- **Technical difficulties reported:** None

Qualitative Feedback

„Učenici su s velikim entuzijazmom koristili aplikacije. Njihovo zanimanje za temu klimatskih promjena se značajno povećalo."
🇭🇷 *Nastavnica, Osnovna škola Titusa Brezovačkog, Zagreb*
(Translation: "Students used the apps with great enthusiasm. Their interest in climate change topics increased significantly.")

„Rad u Co-creation Space-u razvio je suradnički duh i kreativnost, osobito među učenicima koji inače ne sudjeluju τόσο ενεργά."
🇭🇷 *Učitelj, Hrvatska*
(Translation: "Working in the Co-creation Space fostered collaboration and creativity, especially among students who are usually less actively involved.")

„AR alati su dodatno motivirali učenike da istražuju i predlažu vlastite ideje za očuvanje okoliša."
🇭🇷 *Učiteljica razredne nastave, Hrvatska*
(Translation: "The AR tools further motivated students to explore and propose their own ideas for environmental preservation.")

Croatian teachers emphasized the inclusive and participatory nature of the MAC experience. The visual and interactive features of the AR tools appeared to benefit diverse learners, particularly in fostering peer collaboration and creativity.

Suggestions for Improvement

Croatian educators proposed including more guided scenarios or cross-subject activity plans to help integrate MAC more fully into the national curriculum. One teacher suggested that the interface of ARC Create could be further simplified for use with younger students. A few respondents also asked for additional character models and sound options in Croatian.

Conclusion

Teachers in Croatia confirmed that the MAC enhanced pupil motivation, fostered creativity, and improved understanding of environmental issues. The AR components were especially effective in engaging students and encouraging peer collaboration. With no reported technical issues and high satisfaction scores, the Croatian pilot clearly validated MAC's usability and pedagogical value.

7.4 🇲🇹 Malta

In Malta, two different educational settings participated in the MAC piloting: a primary school and a university institution engaged in teacher training. This dual involvement brought diverse insights—from classroom-level implementation to pedagogical reflections at the tertiary level. Maltese educators highlighted the value of MAC for both young learners and future teachers, underscoring its cross-sector potential.

Quantitative Highlights

Number of teachers who tested the MAC: 40

Average rating for pedagogical usefulness (1–5 scale):

- Enhanced pupils' understanding of climate change: 4.67
- Increased student engagement through augmented comics: 4.83
- Supported collaboration and inclusion: 4.5

- Sparked curiosity and creativity: 4.83

Average rating for usability and integration (1–5 scale):

- Ease of setup and use: 4.33
- Content aligned with national curriculum: 4.17
- Overall satisfaction: 4.67

Technical difficulties reported: None
Plan to implement MAC in classroom: 100% of respondents
Would recommend the MAC to others: 100% answered "Yes"

Qualitative Feedback and Quotes

The feedback from teachers in Malta was highly positive, especially regarding the novelty and engagement of the AR components in the classroom. Multiple respondents described moments of genuine excitement among pupils when interacting with the AR-enhanced comics.

"The kids were amazed to see the images come to life. It made the story and message about climate change more real and memorable."
🇲🇹 Teacher at Maria Regina College SPB Primary

Another teacher emphasised the impact on creative thinking and ownership:

"The opportunity to create their own AR scenes using ARC Create gave my students a real sense of authorship. They were eager to share and explain their ideas to their peers."
🇲🇹 ICT Coordinator, Maria Regina College SPB Primary

One of the key strengths highlighted was the accessibility of the platform even for those with little previous exposure to AR:

“I had never used AR before, but the training and tools provided were easy to follow. I felt confident using them with my class.”
🇲🇹 Primary School Teacher

When asked for suggestions, one educator mentioned the need for more localized examples in future versions of the toolkit:

“It would be useful to include examples or comics that relate directly to local environmental issues in Malta. That would make the project even more relevant.”
🇲🇹 Senior Primary Teacher

Suggestions for Improvement

Croatian educators proposed including more guided scenarios or cross-subject activity plans to help integrate MAC more fully into the national curriculum. One teacher suggested that the interface of ARC Create could be further simplified for use with younger students. A few respondents also asked for additional character models and sound options in Croatian.

Conclusion

Teachers in Malta strongly validated the MAC in terms of both its pedagogical value and its usability. The tools were seen as engaging and accessible, fostering active participation and creativity among students. Importantly, every respondent stated they would use the MAC again and recommend it to colleagues—clear evidence of the toolkit’s success in the Maltese pilot.

7.5 🇵🇹 Portugal

Portuguese educators piloted the MAC in a single primary school, where it was integrated into environmental and literacy-focused classroom activities. The teachers had previous experience with digital tools and responded enthusiastically to the interactive and

creative dimensions of MAC. Their input reflected deep consideration of both pedagogical impact and classroom inclusivity.

Quantitative Highlights

Number of teachers who tested the MAC: 20
Institution represented: A single primary school in Portugal. All respondents were experienced female teachers.

Average rating for pedagogical usefulness (1–5 scale):

- Enhanced pupils' understanding of climate change: **5.00**
- Increased student engagement through augmented comics: **5.00**
- Supported collaboration and inclusion: **5.00**
- Sparked curiosity and creativity: **4.75**

Average rating for usability and integration (1–5 scale):

- Ease of setup and use: **4.75**
- Content aligned with national curriculum: **5.00**
- Overall satisfaction: **5.00**

Technical difficulties reported: One minor issue was noted but resolved without incident.
Plan to implement MAC in classroom: 100%
Would recommend the MAC to others: 100%

Qualitative Feedback and Quotes

The feedback from Portuguese teachers demonstrated a uniformly enthusiastic response to the MAC experience, both in terms of classroom application and pupil outcomes. Teachers emphasized how the visual and interactive nature of AR helped students grasp

abstract climate change concepts and boosted engagement, especially among learners with lower academic performance.

"Durante uma aula sobre alterações climáticas, os alunos ficaram fascinados ao ver o urso polar em 3D surgir no meio da sala. Um aluno comentou: 'Parece que ele está mesmo aqui connosco!' – a magia do AR realmente despertou a atenção de todos."
(Translation: "During a class on climate change, the students were fascinated to see the 3D polar bear appear in the middle of the room. One student said: 'It looks like it's really here with us!' – the magic of AR truly captured everyone's attention.")
🇵🇹 *Primary School Teacher, Portugal*

Another teacher commented on MAC's inclusive potential:

"As atividades com a realidade aumentada permitiram que alunos com dificuldades de aprendizagem se envolvessem mais facilmente na aula."
(Translation: "The AR activities enabled students with learning difficulties to engage more easily in class.")
🇵🇹 *Primary School Teacher, Portugal*

A third respondent mentioned the curriculum fit:

"O conteúdo foi perfeitamente alinhado com os nossos temas ambientais. Usei-o durante um projeto sobre biodiversidade e teve um impacto imediato."
(Translation: "The content was perfectly aligned with our environmental topics. I used it during a biodiversity project and it had immediate impact.")
🇵🇹 *Teacher, Portugal*

Suggestions for Improvement

Teachers suggested a few refinements for future iterations of the MAC tools:

- Add more localized 3D models (e.g. Iberian wildlife, forest fires, drought scenarios)
- Enable offline use, especially in areas with unstable internet
- Provide classroom-ready guides or cross-curricular extension ideas

Conclusion

The MAC piloting in Portugal demonstrated a near-perfect rating in both engagement and integration. Despite the small sample size, the consistency in ratings and the depth of qualitative feedback strongly affirm the toolkit's educational value. Teachers expressed clear intent to reuse the tools and appreciated their accessibility, even for those with limited AR experience.

7.6 🇪🇸 Spain

The MAC was piloted in several Spanish regions, including Madrid, Barcelona, and Andalusia, involving teachers from a variety of school types. Spanish educators implemented the tools during science and citizenship lessons, linking them to climate education and learner empowerment. Their feedback emphasised the importance of engagement, curriculum fit, and usability in multi-level classrooms.

Quantitative Highlights

Number of teachers who tested the MAC: 20
Institutions represented: Schools across Madrid, Barcelona, and Andalusia

Average rating for pedagogical usefulness (1–5 scale):

- Enhanced pupils' understanding of climate change: **4.60**
- Increased student engagement through augmented comics: **4.80**
- Supported collaboration and inclusion: **4.60**
- Sparked curiosity and creativity: **4.40**

Average rating for usability and integration (1–5 scale):

- Ease of setup and use: **4.20**
- Content aligned with national curriculum: **4.60**
- Overall satisfaction: **4.60**

Technical difficulties reported: Minor, related to older tablets and classroom Wi-Fi
Plan to implement MAC in classroom: 100%
Would recommend the MAC to others: 100%

Satisfaction and Implementation Highlights

Educators in Spain responded very positively to the MAC tools, especially in their ability to boost engagement and make abstract climate concepts tangible. The MAC was praised for encouraging peer collaboration and participation, particularly among students with varying learning needs. The strong alignment of the content with curricular goals was also noted.

Teachers described the toolkit as generally intuitive, although some experienced technical limitations due to school equipment. Nevertheless, all respondents managed to integrate MAC into their teaching, often using it as part of environmental science projects or creative writing modules.

Representative Quotes from Teachers

"It was impressive to see how quickly my students became interested and even guided each other during the activity."
🇪🇸 *Primary School Teacher, Madrid*

“The MAC provided an exciting new perspective on climate change that moved the topic beyond abstract concepts.”
🇪🇸 *Headteacher, Barcelona*

“Algunos alumnos que habitualmente no participan fueron los primeros en levantar la mano para usar la herramienta.”
(Translation: “Some students who usually don’t participate were the first to raise their hands to use the tool.”)
🇪🇸 *Educadora ambiental, Andalucía*

Suggestions for Improvement

Teachers recommended additional Spanish-language lesson templates and contextualised content, such as AR scenes focusing on drought, wildfires, or desertification in southern Spain. They also suggested improvements to the Co-creation Space to make it easier to use independently by younger pupils. Some called for printed guides and video tutorials in Spanish to support implementation across all regions.

Conclusion

The Spanish piloting phase confirmed the MAC’s value as a dynamic, interdisciplinary educational tool. The toolkit succeeded in raising awareness about environmental issues while simultaneously fostering creativity, collaboration, and digital skills. Minor adjustments related to localisation and technical support would enhance its long-term sustainability and accessibility in Spain.

8. Conclusions

The validation of the MIRACLE Augmented Classroom (MAC) across six European countries—**Ireland, Greece, Croatia, Malta, Portugal, and Spain**—has demonstrated the strong pedagogical value, usability, and impact of the toolkit in primary education settings. The piloting revealed a high level of satisfaction among teachers and strong alignment of the MAC tools with national curricula and classroom needs, particularly in the context of environmental and climate change education.

Quantitatively, the MAC received consistently high scores across all evaluation domains. Teachers reported that the **AR tools enhanced students' understanding of complex environmental concepts**, boosted motivation and curiosity, and fostered collaborative learning environments. The average ratings for pedagogical usefulness ranged between **4.4 and 5.0 out of 5**, while ratings for usability and integration remained similarly high. Most notably, in all six countries, **100% of the teachers surveyed expressed their intention to use the MAC again and recommend it to colleagues**, a strong indicator of overall success.

Qualitative data further enriched these findings. Teachers praised the **visual, interactive, and creative dimensions** of the MAC tools, noting their potential to include pupils of varying academic abilities and support differentiated instruction. Memorable moments of student engagement and self-expression were frequently mentioned, and many respondents shared stories of students who were typically passive becoming actively involved through the AR-enhanced learning activities.

Despite the overwhelmingly positive feedback, the validation process also identified areas for further improvement. These include refining the technical performance of AR tools (especially for older or low-spec devices), increasing the quantity and cultural relevance

of localized content, and enhancing onboarding materials for teachers. These findings are invaluable for ensuring that the MAC continues to evolve as an inclusive, teacher-friendly, and contextually adaptable educational solution.

In conclusion, the validation of Work Package 4 confirmed that the MAC delivers on its promise to **transform climate change education through augmented reality and co-creation**. It offers a compelling model for integrating immersive technologies into everyday teaching, fostering not only environmental awareness but also critical thinking, creativity, and collaboration among Europe's youngest learners. The success of the piloting phase positions the MAC as a scalable innovation, ready for wider uptake in classrooms beyond the MIRACLE consortium.

9. Recommendations

Based on the feedback collected from 143 educators across six countries, the following recommendations are proposed to enhance the usability, accessibility, and educational value of the MIRACLE Augmented Classroom (MAC):

9.1 Localisation of Content

Teachers across all countries highlighted the need for more **contextually relevant AR content**. This includes:

- Country-specific environmental scenarios (e.g., Iberian drought and wildfires, Irish wetlands, Maltese coastal issues).
- Local fauna and flora 3D models.
- Curriculum-aligned lesson plans tailored to national standards and learning objectives.

9.2 Enhancement of the Co-Creation Space

While the Co-Creation Space was praised for encouraging pupil creativity and collaboration, users recommended:

- Clearer onboarding instructions for pupils and teachers.
- Age-appropriate design features, particularly for younger learners.
- Simplification of the ARC Create interface for ease of use in lower primary grades.

9.3 Improved Technical Support and Usability

Although technical difficulties were generally minimal, recurring suggestions included:

- **Offline or preloaded versions** of the AR scenes to reduce dependency on internet speed and stability.
- **Printable user guides and video tutorials** in national languages.
- More detailed troubleshooting support for device compatibility issues, especially in schools with older hardware.

9.4 Expanded Teacher Training and Resources

Several teachers, especially those with limited AR experience, expressed the need for:

- Brief, **modular training videos** to build confidence with MAC tools.
- **Cross-curricular teaching scenarios** that demonstrate how MAC can be used across subjects (e.g., science, language, geography).
- **Classroom management strategies** when using AR with large or mixed-ability groups.

9.5 Inclusion and Accessibility Features

Suggestions from teachers working with students with additional needs included:

- Visual prompts and simplified instructions within the apps.
- More inclusive AR design, such as **audio descriptions**, **text-to-speech** functions, or **language support** for multilingual environments.

9.6 Refinement of AR Technical Features

Educators recommended ongoing improvements to:

- AR **loading speed** and **response time**.
- **Interaction accuracy** and stability of 3D elements.
- Visual clarity and alignment with physical markers (especially in tablet use).

These recommendations reflect the collective experience of educators during the piloting phase and aim to inform the iterative development of the MAC. Their implementation will support wider adoption and ensure that the toolkit continues to meet the evolving needs of European classrooms.

To demonstrate that the following recommendations are grounded in the actual experiences and suggestions of educators who participated in the MAC piloting phase, a cross-country evidence matrix has been compiled. This table maps each key recommendation theme to the countries where it was explicitly or consistently raised in the validation questionnaires, ensuring transparency and alignment with the collected data.

Table 1

Cross-country Evidence Matrix Supporting Recommendations

This table maps the key recommendation themes to the countries where they were explicitly or consistently suggested in teachers' responses to the WP4 validation questionnaire.

Recommendation Theme	Countries where suggested	Representative Topics Raised
1. Localisation of Content	🇵🇹 Portugal 🇲🇹 Malta 🇬🇷 Greece 🇪🇸 Spain	Need for local fauna/flora models, context-specific environmental issues (e.g. forest fires, drought), alignment with national curriculum.
2. Improved Usability of Co-Creation Space	🇭🇷 Croatia 🇬🇷 Greece 🇪🇸 Spain	Suggestions to simplify ARC Create interface for younger pupils, clearer student instructions, age-appropriate guidance.
3. Offline Functionality & Technical Support	🇲🇹 Malta 🇬🇷 Greece 🇪🇸 Spain	Requests for offline mode, AR loading optimisations, help with old devices or low Wi-Fi.
4. Teacher Training & Integration Support	🇮🇪 Ireland 🇬🇷 Greece 🇭🇷 Croatia	Desire for quick-start videos, classroom-ready lesson plans, and tips for classroom management with AR.
5. Inclusion & Accessibility Features	🇵🇹 Portugal 🇭🇷 Croatia 🇪🇸 Spain	Feedback on AR helping low-performing students; recommendations for visual aids, multilingual options, and simplified user flow.

6. Technical Refinement of AR Tools	Greece Croatia Spain	Comments about slow AR loading, marker recognition issues, and general stability improvements.

Annex I: Survey Monkey - Survey

Demographic Information

(*Mandatory*)

1. **Name**: _____

2. **Surname**: _____

3. **Email address**: _____

4. **Country**:

Greece
Croatia
Ireland
Malta
Spain
Portugal
Other country => Specify

5. **School/Organization name**: _____

6. **Type of school**:

○ Primary

○ Secondary

○ Other: _____

7. Gender:

- Female

- Male

- Non-binary / Third gender
- Prefer not to say

8. Role in the school/organization:
- Teacher
- Headteacher/Principal
- ICT Coordinator
- Support Staff (e.g., SEN specialist)
- Administrator
- Other (please specify): _____

9. Years of teaching experience:

○ 0–5 years

○ 6–10 years

○ 11–20 years

○ More than 20 years

10. Have you used Augmented Reality (AR) tools before?

○ Yes

○ No

11. Did you participate in the full MOOC?

○ Yes

○ Partially

○ No

12. Did you test the MIRACLE Augmented Classroom (MAC) activities?

○ Yes

○ Not yet

○ No

The validation tool assesses both the **educational impact** and **technical performance** of the AR-powered classroom activities.

Section A: Pedagogical Usefulness

(Likert Scale: 1 = Strongly disagree to 5 = Strongly agree)

1. The AR tools enhanced my pupils' understanding of climate change.
2. The augmented comics increased student engagement.
3. The MAC supported collaboration and inclusion in my class.
4. I noticed greater curiosity and creativity among pupils using the MAC.

Section B: Usability and Integration

(Likert Scale + Yes/No with comments)

5. The AR application was easy to set up and use.
6. The content was relevant and aligned with my national

curriculum.

7. (Yes/No) I experienced technical difficulties.
   If Yes, please explain: _____
8. (Yes/No) I was able to integrate the MAC into a classroom project.
   If No, why not? _____

Section C: Impact & Suggestions (Open-ended)

9. Describe a memorable moment from your MAC session: _____
10. What would you like to add or change in the MAC toolkit? _____

2. Technical Validation Checklist

(To be filled out by teachers or facilitators; Rate 1 = Poor to 5 = Excellent, with comment field)

Indicator	Rating (1–5)	Comments
Mode of interaction (intuitive, engaging)		
Response time (speed of AR functions)		
Interaction accuracy		
Sound and visual quality		
Integration with classroom material		
Ease of setup and troubleshooting		
GDPR and data privacy compliance		
Student engagement levels		
Compatibility with devices		

Annex II: Sample Quotes by Country

This annex presents a selection of teacher testimonials collected during the validation of the MIRACLE Augmented Classroom (MAC) tools. Drawn directly from the national survey responses submitted as part of the WP4 piloting phase, the quotes reflect educators' authentic experiences with the MAC in diverse classroom settings. The statements highlight observed impact on student engagement and learning, practical implementation feedback, and suggestions for further development. Where applicable, quotes are presented in their original language along with an English translation to preserve the voice and context of the respondents.

🇮🇪 Ireland

"The comics, the layering of climate facts, and the child-friendly images made even complex issues like climate justice understandable for my pupils."
— *Teacher, Carlow Town Educate Together National School*

"The class was totally immersed. They kept pointing at the screen, asking questions, and suggesting what we could do as a class for the environment."
— *Primary Teacher, Carlow Town Educate Together National School*

"It helped me, as a teacher, to tackle climate change in a more structured way without overwhelming my class."
— *Educator, Ireland*

"Augmented Reality was new for my students and sparked instant curiosity. Some of the quieter ones became very active in the session."
— *Teacher, Carlow Educate Together NS*

“Students with additional needs found the MAC activities accessible and fun. The visual element helped with understanding.”
— SEN Coordinator, Carlow Educate Together NS

“For younger children, additional visual prompts in the app would help with navigation.”
— Primary School Teacher, Junior Class

“The co-creation space is a fantastic idea but would benefit from clearer onboarding instructions.”
— ICT Coordinator

“Sometimes the AR models didn’t load. I think it depends on the strength of the Wi-Fi and the quality of the tablet camera.”
— Teacher, Carlow Educate Together NS

🇬🇷 Greece

“Τα παιδιά ξετρελάθηκαν! Ήθελαν να ξαναδούν το AR και να δημιουργήσουν τα δικά τους comics.”
(Translation: “The children were thrilled! They wanted to revisit the AR and create their own comics.”)
— Primary Teacher, 4th Primary School of Chania

“Οι μαθητές συνεργάστηκαν με ενθουσιασμό. Η Εύα, που συνήθως μένει στο περιθώριο, πήρε την πρωτοβουλία να ηγηθεί της ομάδας της.”
(Translation: “The students collaborated enthusiastically. Eva, who is usually reserved, took the initiative to lead her group.”)
— Teacher, 9th Primary School of Rethymno

🇭🇷 Croatia

“Učenici su s velikim entuzijazmom koristili aplikacije. Njihovo zanimanje za temu klimatskih promjena se značajno povećalo.”

(Translation: "Students used the apps with great enthusiasm. Their interest in climate change topics increased significantly.")
— Nastavnica, Osnovna škola Titusa Brezovačkog, Zagreb

"Rad u Co-creation Space-u razvio je suradnički duh i kreativnost, osobito među učenicima koji inače ne sudjeluju τόσο ενεργά."
(Translation: "Working in the Co-creation Space fostered collaboration and creativity, especially among students who are usually less actively involved.")
— Učitelj, Hrvatska

"AR alati su dodatno motivirali učenike da istražuju i predlažu vlastite ideje za očuvanje okoliša."
(Translation: "The AR tools further motivated students to explore and propose their own ideas for environmental preservation.")
— Učiteljica razredne nastave, Hrvatska

🇲🇹 Malta

"The kids were amazed to see the images come to life. It made the story and message about climate change more real and memorable."
— Teacher at Maria Regina College SPB Primary

"The opportunity to create their own AR scenes using ARC Create gave my students a real sense of authorship. They were eager to share and explain their ideas to their peers."
— ICT Coordinator, Maria Regina College SPB Primary

"I had never used AR before, but the training and tools provided were easy to follow. I felt confident using them with my class."
— Primary School Teacher

"It would be useful to include examples or comics that relate directly to local environmental issues in Malta. That would make the project

even more relevant."
— *Senior Primary Teacher*

🇵🇹 Portugal

"Durante uma aula sobre alterações climáticas, os alunos ficaram fascinados ao ver o urso polar em 3D surgir no meio da sala. Um aluno comentou: 'Parece que ele está mesmo aqui connosco!' – a magia do AR realmente despertou a atenção de todos."
(Translation: "During a class on climate change, the students were fascinated to see the 3D polar bear appear in the middle of the room. One student said: 'It looks like it's really here with us!' – the magic of AR truly captured everyone's attention.")
— *Primary School Teacher, Portugal*

"As atividades com a realidade aumentada permitiram que alunos com dificuldades de aprendizagem se envolvessem mais facilmente na aula."
(Translation: "The AR activities enabled students with learning difficulties to engage more easily in class.")
— *Primary School Teacher, Portugal*

"O conteúdo foi perfeitamente alinhado com os nossos temas ambientais. Usei-o durante um projeto sobre biodiversidade e teve um impacto imediato."
(Translation: "The content was perfectly aligned with our environmental topics. I used it during a biodiversity project and it had immediate impact.")
— *Teacher, Portugal*

🇪🇸 Spain

"It was impressive to see how quickly my students became interested and even guided each other during the activity."
— *Primary School Teacher, Madrid*

“The MAC provided an exciting new perspective on climate change that moved the topic beyond abstract concepts.”
— Headteacher, Barcelona

“Algunos alumnos que habitualmente no participan fueron los primeros en levantar la mano para usar la herramienta.”
(Translation: “Some students who usually don’t participate were the first to raise their hands to use the tool.”)
— Educadora ambiental, Andalucía

“Fue una herramienta muy motivadora para los alumnos. Pudieron visualizar mejor conceptos difíciles.”
(Translation: “It was a very motivating tool for the students. They were able to better visualise difficult concepts.”)
— Teacher, Jaitek Network School

“Me gustaría que hubiera más contenido adaptado al currículo local.”
(Translation: “I would like more content aligned with the local curriculum.”)
— Educator, Spain

“Le contenu était super mais certains élèves ont eu des difficultés à comprendre comment déclencher l'animation AR.”
(Translation: “The content was great, but some students had difficulty figuring out how to trigger the AR animation.”)
— Francophone Teacher, Spain

Annex III – Full Likert-Scale Results by Country

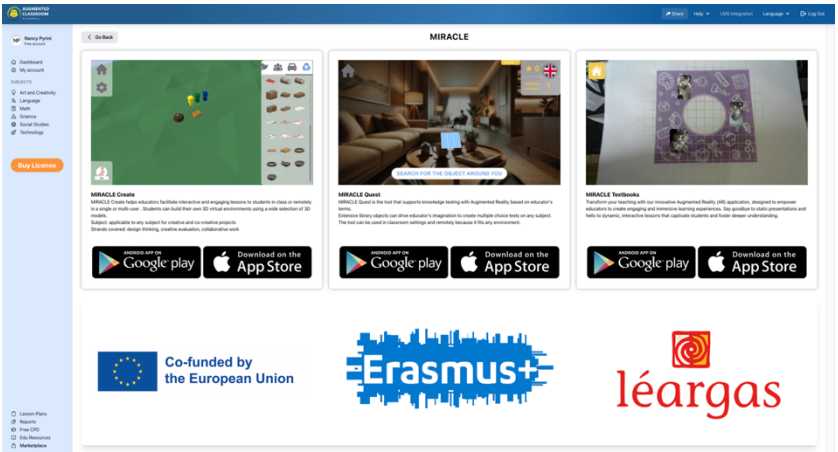
This annex presents a comparative overview of teachers' quantitative evaluations of the MIRACLE Augmented Classroom (MAC) tools, based on Likert-scale responses collected during the WP4 piloting phase. Educators in each participating country rated a set of key indicators related to usability, technical performance, pedagogical integration, and student engagement on a 1–5 scale. The table below summarises the average scores per indicator, providing a cross-country perspective on the perceived effectiveness and functionality of the MAC toolkit.

Indicator	Croatia	Greece	Ireland	Portugal	Spain
Classroom integration	4.59	4.6	4.15	4.1	4.15
Device compatibility	4.55	4.65	4.18	4.0	4.3
Ease of setup	4.41	4.55	4.09	3.9	4.05
GDPR compliance	4.55	4.7	4.26	3.9	4.25
Interaction accuracy	4.5	4.65	4.01	4.0	4.25
Mode of interaction	4.59	4.6	4.13	4.0	4.15
Response time	4.5	4.65	4.01	3.95	4.45
Sound and visual quality	4.73	4.85	4.21	4.0	4.3
Student engagement	4.73	4.7	4.12	3.85	4.1

Annex IV: MAC Platform Screenshots

To complement the validation findings and support the usability analysis, this annex presents selected screenshots from the MIRACLE Augmented Classroom (MAC) platform. These visuals illustrate the structure and interface of the MAC toolkit's three key applications — **Miracle Create**, **Miracle Quest**, and **Miracle Textbooks** — as well as the unified access environment used by piloting teachers. The screenshots offer evaluators a clearer view of the platform's design, accessibility, and cross-platform availability via mobile app stores. This visual overview further reinforces the MAC's potential for integration in diverse educational settings.

Figure A4.1
Homepage of the MIRACLE Augmented Classroom platform, showcasing the three main applications: *Miracle Create* (3D model builder for creative projects), *Miracle Quest* (gamified AR knowledge testing tool), and *Miracle Textbooks* (interactive AR learning content). The platform is accessible via Android and iOS and includes EU and Erasmus+ branding in accordance with co-funding requirements.

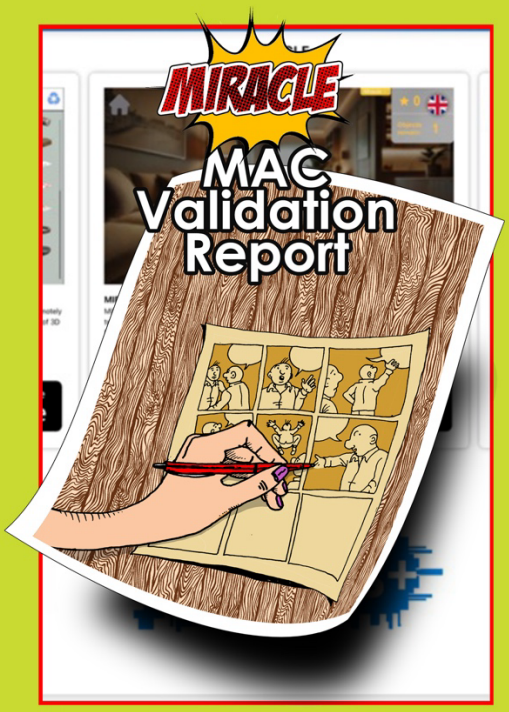


Acknowledgements

The consortium of the MIRACLE project wishes to express its sincere gratitude to all the educators, school leaders, and teacher trainers who participated in the piloting of the MIRACLE Augmented Classroom (MAC) across Ireland, Greece, Croatia, Malta, Portugal, and Spain. Their enthusiasm, creativity, and critical feedback were invaluable in validating the MAC tools and shaping their future development.

Special thanks are extended to the national coordinators and partner organisations in each country, whose commitment and coordination ensured the successful implementation of the WP4 activities. We also warmly acknowledge the technical team for their responsive support and continuous improvement of the digital tools during the pilot phase.

Finally, we thank the students who engaged with the MAC tools and brought climate-related learning to life through curiosity and imagination. Their participation reminded us of the transformative potential of education when paired with innovation and purpose.



This report presents the validation findings of Work Package 4 (WP4) of the MIRACLE project—"coMics and IllustRations Augmented to tackle CLimate change in primary Education"—which focused on the implementation and evaluation of the MIRACLE Augmented Classroom (MAC). Developed as a comprehensive toolkit combining Augmented Reality (AR) tools and a digital co-creation space, the MAC aims to foster climate literacy, digital competence, and pupil engagement through immersive, creative learning experiences.

The validation activities were conducted between May and July 2025 across six partner countries: Ireland, Greece, Croatia, Malta, Portugal, and Spain. A total of 143 educators participated, including primary school teachers, school leaders, and teacher trainers. The validation employed a mixed-methods approach, incorporating Likert-scale surveys, technical checklists, and open-ended feedback, to assess four key dimensions: pedagogical usefulness, usability and integration, educational impact, and user feedback for refinement.