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IGNITE

ĸEPORT WITH EVALUATION OF INNOVATIVE LEARNING METHODS AND RECOMMENDATIONS FOR USING INNOVATIVE LEARNING METHODS IN STEAM STUDY PROGRAMMES

WP2
A2.4
RESPONSIBLE PARTNER: INNOVATION HIVE

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Executive Summary

The IGNITE evaluation demonstrates a coherent and transferable STEAM learning model combining empathy-informed design, nano-learning, gamified practice, competence self-monitoring and challenge-based application. The strongest overall finding is that these elements create the greatest educational value when implemented as an integrated learning pathway rather than as separate project outputs.

The final evaluation combines evidence from the Empathic Questionnaire completed by 108 students from five European HEIs, internal nanomodule evaluation by 11 partner staff including five developers, student workshop feedback, Virtual Learning Garden analytics, Competence Monitoring Application data, staff training, Innovation Marathon evaluation and stakeholder feedback from multiplier events and the Final Conference.

The learner-needs analysis strongly supported the project's pedagogical choices. Visual information was preferred by 47.2% of students, 32.4% preferred complex topics broken into smaller steps, 34.3% preferred digital videos organised through clear sequential progression, and 38.9% reported the strongest emotional connection when they could try content out practically. These findings support concise, visually structured learning combined with practical application and learner choice.

The nano-learning approach was positively evaluated by both staff and students. Eleven partner staff evaluated the modules, including five developers, and student workshop participants gave the nano-learning components an average rating of 4.50/5. The Virtual Learning Garden recorded 32 participants and 63 quiz attempts, with an average achievement of 80.3%, providing evidence of active engagement beyond passive content consumption. The Competence Monitoring Application registered 60 users, of whom 44 unique users actively engaged with assessments across all ten nanomodules. Students rated the usefulness of pre-/post-assessment 4.19/5 and the application's support for learning 4.13/5.

The staff training involved 16 higher-education staff members from all six partner countries, exceeding the planned target. The Innovation Marathon translated the learning approach into authentic challenge-based application and resulted in eight sustainability-oriented student projects, assessed by an international jury of seven evaluators.

External stakeholder validation further confirmed the relevance and transferability of the project. Across 30 responses from multiplier events and the Final Conference, overall satisfaction reached 4.70/5, while 70% of respondents expressed interest in using or promoting IGNITE results in the future and a further 20% responded "Maybe".

The evidence supports the IGNITE Learn–Practice–Assess–Apply model. Future implementation should focus on stronger integration between tools, simplified access, mobile and accessible design, more standardised assessment, clearer cross-platform analytics and explicit curricular embedding. Long-term sustainability will depend on institutional ownership, continued staff capacity building, maintenance of digital resources, repeated course integration and systematic monitoring of learner outcomes and post-project adoption.

1. Introduction

1.1 Background of the IGNITE project

IGNITE addresses the need for higher education to prepare learners for sustainability transitions, emerging technologies and innovation-oriented work. Its educational model links STEAM knowledge with sustainability, entrepreneurship, digital competence and transversal skills. The project combines learner-centred design with digital resources and practical application, recognising that effective competence development requires more than content transmission.

The model is implemented through connected components: an Empathic Questionnaire mapping students' learning preferences and needs; short video-based nano-learning modules; a Virtual Learning Garden with interactive exercises and gamified recognition; an online competence-monitoring application incorporating pre- and post-assessment; an e-assistant/e-advisor supporting personalised learning and career guidance; and an Innovation Marathon in which students address environmental and societal challenges under academic or industry mentorship. Together, these components form an integrated learning pathway from understanding learner needs and acquiring knowledge to practice, competence monitoring, feedback and practical application.

The thematic scope of the nano-learning modules spans sustainable food production and consumption, sustainable ship biofouling management, sustainable construction, social innovation for sustainable futures, sustainable materials for the green and digital transition, virology and environmental sustainability, materials structure and properties, natural materials and biomaterials, plasma technology and plasma physics. This range reflects the interdisciplinary character of contemporary STEAM education and enables the IGNITE learning approach to be tested across different scientific and technological fields.

1.2 Objectives of the evaluation

The evaluation has the following objectives:

- to assess the relevance, quality and educational value of the IGNITE learning model and its innovative learning methods;
- to examine the usability, acceptance and educational usefulness of the developed digital tools;
- to assess learner engagement and the contribution of the developed approaches to knowledge and competence development;
- to evaluate the applicability and transferability of the developed learning approaches within STEAM higher education programmes;
- to identify strengths, limitations and priorities for further improvement;
- to formulate evidence-based and actionable recommendations for higher education institutions, educators, developers and other relevant stakeholders, including recommendations for further improvement of the IGNITE digital learning ecosystem.

1.3 Scope of the report

The report evaluates the design, implementation and available evidence related to the main components of the IGNITE learning model: student-centred learning design, nano-learning modules, the Virtual Learning Garden, the IGNITE competence-monitoring application, staff training and the Innovation Marathon. Supporting evidence from student workshops and external stakeholder feedback is also used to assess the relevance, usability, applicability and transferability of the developed approaches.

The evaluation combines quantitative and qualitative evidence from questionnaires, learning-platform analytics, project documentation, participant feedback and expert assessment. Particular attention is given to students' learning preferences, the quality and usability of nano-learning modules, engagement with the Virtual Learning Garden, user experience with the IGNITE application, competence-oriented learning, challenge-based learning through the Innovation Marathon, and the potential for integrating these approaches into STEAM higher education programmes.

Where final competence-development data from the IGNITE application are available, they are used to complement questionnaire-based and platform-based evidence and to assess changes between pre- and post-assessment. Where such data are not available or cannot be paired at individual level, conclusions are limited to the evidence that can be reliably demonstrated.

The findings are subsequently translated into recommendations concerning curriculum design, teaching methods, digital learning tools, assessment, student engagement, collaboration, accessibility, sustainability and institutional adoption.

2. Methodology

The evaluation of the innovative learning methods and digital tools developed within the IGNITE project was conducted using a mixed-methods approach, combining quantitative and qualitative data collected throughout the project implementation. The evaluation aimed to assess the effectiveness, usability, and educational value of the developed learning methods, analyse their contribution to students' knowledge and competence development, and formulate evidence-based recommendations for their integration into STEAM higher education programmes.

2.1 Evaluation framework

The evaluation framework was designed to provide a comprehensive assessment of the innovative learning methods and digital tools developed within the IGNITE project. Rather than relying on a single source of information, the evaluation combined multiple complementary sources of evidence, enabling triangulation of the collected data and increasing the reliability of the findings.

The evaluation framework was based on the following sources of evidence:

- Project documentation, including the Empathic questionnaire report, Nanomodules development plan, Innovation marathon guidelines and implementation procedure, student project templates, presentation templates and Innovation marathon evaluation forms. These documents provided the pedagogical and methodological basis for the developed learning methods.
- Evaluation questionnaires completed by students, professors, mentors and external stakeholders during different phases of the project. The questionnaires evaluated the developed nanomodules, virtual workshops, staff training, Innovation Marathon, stakeholder events and digital learning tools. The evaluation included both structured quantitative questions and open-ended questions, allowing the analysis to combine numerical ratings with participants' qualitative feedback.
- IGNITE competence monitoring application, which was used to support pre- and post-assessment, competence monitoring and learning progress tracking. User statistics and available anonymised assessment data were used as complementary evidence of the use and educational role of the application.
- Virtual learning garden, providing anonymised learning analytics on user participation, quiz activity, successful quiz completion and learning achievement, in addition to evidence on interactive exercises, progress monitoring and gamified recognition.
- IgniteSphere Community, providing information on community participation, user registrations and engagement with the developed online collaboration platform.
- Innovation marathon, including student project documentation, student project evaluations, mentoring activities, evaluation committee scores, and participant feedback collected throughout the challenge-based learning process.
- Stakeholder events, including National Multiplier Events and the Final Conference, where external stakeholders evaluated the relevance, quality and future applicability of the developed project results. These responses provided an external perspective on the applicability, transferability and potential future use of the IGNITE results.
- Project monitoring data and KPIs, including attendance lists, agendas, participant statistics, dissemination indicators, website analytics, YouTube analytics, social media statistics and other project implementation evidence used to verify project performance and achievement of project objectives.

- Scientific publications and conference papers developed within the project, providing additional scientific evidence related to empathy-based learning design, learning preferences, nanolearning, gamification, challenge-based learning, competence development and innovative approaches to STEAM education. These publications supported the interpretation of the evaluation results and the formulation of recommendations.

Quantitative questionnaire results were interpreted alongside qualitative comments, digital learning analytics, expert assessments and project documentation. Triangulation was applied where the same or related dimensions were addressed by more than one source—for example, students' learning preferences, staff assessment of nanomodule quality, student evaluation of learning activities, VLG learning analytics and feedback on the IGNITE application.

Evaluation domain	Primary evidence	Analytical focus
Student-centred design	Empathic questionnaire report (n=108)	Cognitive and metacognitive preferences, motivation, emotional connection, cross-country variation
Nanolearning modules	Nanomodule guide and evaluation (n=11; developers n=5)	Development process, quality, usability, accessibility, engagement and applicability
Student learning experience	Student Virtual Workshops Evaluation (n=33)	Perceived quality and usefulness of nanomodules, VLG and digital tools; engagement, learning experience and workshop implementation
Digital application and staff training	Online application and staff-training evaluation (n=10)	Usability, information architecture, usefulness, training quality and transferability
Virtual Learning Garden	VLG learning environment and anonymised learning analytics (n=32 participants)	Participation, quiz engagement, learning achievement, gamification and progress monitoring
Innovation Marathon	Organisation guidelines, participant evaluation (n=6), and expert assessment of 8 student projects by 7 evaluators	Challenge-based learning, mentoring, assessment, collaboration, project quality and practical application
External stakeholder validation	Stakeholder Event Feedback Questionnaire (n=30)	Relevance, quality, applicability, transferability and potential future use of project results
Competence monitoring	IGNITE Competence Monitoring Application and available anonymised user/assessment data	Use of the application, learning progress and, where available, changes between pre- and post-assessment

2.2 Data collection methods

Data were collected continuously throughout the IGNITE project's implementation using several complementary methods.

The primary source of information was online evaluation questionnaires designed for different target groups, including students, lecturers, mentors, and external stakeholders. These questionnaires collected both quantitative ratings and qualitative feedback regarding the effectiveness, usability, and educational value of the developed learning methods and digital tools. Different questionnaires were used at different stages of implementation, enabling the evaluation to capture the perspectives of learners, educators, project partners, mentors and external stakeholders.

To assess competence development, the project employed the IGNITE Competence Monitoring Application, allowing participants to complete pre- and post-assessments associated with the developed learning content and to monitor their learning progress. Available aggregated and anonymised application data were used to complement questionnaire-based evidence. Where comparable pre- and post-assessment data were available, they were used to examine changes in knowledge and competence development.

Additional evidence was obtained through digital platform analytics, including usage statistics from the IGNITE Competence Monitoring Application, the Virtual Learning Garden and the IgniteSphere Community. Indicators such as registered users, active participation, quiz attempts, successful quiz completion, learning achievement, issued certificates or badges, participation rates and user engagement were analysed.

For the Virtual Learning Garden, anonymised LearnDash analytics were used to examine participation and interaction with the learning activities. These included the number of participants, quiz attempts, successful quiz attempts and average quiz achievement.

The evaluation also incorporated project documentation, including implementation guidelines, learning materials, attendance lists, dissemination records and project monitoring data.

Furthermore, expert evaluation played an important role during the Innovation Marathon, where student projects were assessed by an international evaluation committee using predefined evaluation criteria. The committee provided quantitative scores for eight student projects, together with qualitative feedback on project quality, innovation potential, sustainability, feasibility and potential impact.

Finally, qualitative feedback collected through open-ended questionnaire questions and expert comments was analysed to identify strengths, challenges, and opportunities for improving the developed learning methods and digital tools.

All questionnaire responses, platform analytics and other participant-related data included in this report are presented in aggregated or anonymised form. No personal identifiers are reported in the evaluation results.

2.3 Participants

Dataset	Participants	Geographical/institutional coverage	Important note
Empathic questionnaire	108 students	Five HEIs in Slovenia, Norway, Spain, France and Belgium	Largest evidence base; institution shares ranged from 13.9% to 27.8%.
Nanomodule evaluation	11 partner staff/evaluators	Project partnership	5 respondents participated in nanomodule development; 6 participated in evaluation only
Online Application & Staff Training Evaluation	10 evaluation respondents; training cohort: 16 HE staff	Greece 40%, Slovenia 30%, France 10%, Spain 10%, Norway 10%	70% female; 90% held a Master's degree or PhD.
Student Virtual Workshops Evaluation	33 respondents	Participants from Slovenia, France, Spain and Belgium	Predominantly students; provides direct learner feedback on the developed learning methods and tools
Virtual Learning Garden analytics	32 participants	Online / international learning environment	Anonymised platform data used to assess participation and quiz engagement
Innovation Marathon participant evaluation	6 respondents	Participants involved in the Innovation Marathon	Included student and mentor/professor perspectives
Innovation Marathon expert assessment	7 evaluators; 8 student projects	International evaluation committee	Projects assessed using a common 100-point evaluation framework
Stakeholder Event Feedback	30 respondents	National Multiplier Events and Final Conference	External validation of relevance, quality, applicability and future use of IGNITE results

IGNITE Competence Monitoring Application	60 registered users; 44 unique active users; 70 module-level participations	Online / project participants	User statistics and available anonymised pre-/post-assessment data

2.4 Evaluation criteria

The evaluation of the IGNITE learning methods and digital tools was based on a set of predefined evaluation criteria reflecting both the project objectives and the expected impact on higher education. The criteria were applied across the different evidence sources where relevant, allowing findings from students, staff, mentors, external stakeholders, platform analytics and expert assessment to be interpreted within a common framework.

The following evaluation criteria were considered:

- **Quality and effectiveness**, assessing whether the developed learning approaches and project results were implemented to an appropriate standard and supported their intended educational purpose.
- **Relevance**, referring to the extent to which the developed learning methods addressed the needs of students, teachers, and higher education institutions.
- **Usability**, assessing the ease of use, accessibility and user-friendliness of the developed digital tools and learning resources.
- **Learner engagement**, examining participants' motivation, interaction, collaboration and active involvement throughout the learning process.
- **Competence development**, evaluating the contribution of the developed learning methods to the development of sustainability, entrepreneurial, digital and transversal competences.
- **Sustainability**, assessing the potential of the developed approaches to support long-term competence development and promote sustainable innovation in higher education.
- **Applicability**, evaluating the feasibility of integrating the developed learning methods and digital tools into existing STEAM study programmes.
- **Transferability**, examining the potential for adapting and implementing the developed approaches in different higher education institutions, countries and educational contexts.

The combined application of these evaluation criteria enabled a comprehensive assessment of the effectiveness of the IGNITE project results and formed the basis for the recommendations presented in the following chapters.

3. Designing Student-Centred Learning

3.1 Students' learning preferences

The student evidence provides a clear design signal: learning resources should be visual, structured and connected to application. The analysis was based on responses from 108 students from five participating higher education institutions in Slovenia, Norway, Spain, France and Belgium.

Visual information was selected by 47.2% of respondents, compared with 26.9% written, 13.9% hands-on and 12% auditory. When asked what helps most in learning something new, 33.3% selected diagrams or visual explanations and 28.7% selected trying it out. These results favour multimodal design with visual explanation followed quickly by practice.

Motivation was driven principally by relevance to life or future goals (45.4%) and hands-on experience (27.8%). Emotional connection followed a similar pattern: 38.9% selected practical trial and 25% visualisation. A further 24.1% reported feeling most emotionally connected when discussing content with others, indicating that collaborative interaction can also contribute to engagement. Therefore, an effective nanomodule should answer “why this matters” at the start and give the learner an action, decision, experiment or problem before the end.

Preferences varied with subject matter. Sustainable innovation was best supported by infographics, videos or diagrams (37%) and projects or experiments (30.6%). Entrepreneurial innovation produced a different profile: expert panels or podcasts ranked first (32.4%), collaborative workshops second (26.9%) and visual aids third (25%). This variation suggests that the preferred learning approach is context-dependent rather than uniform across topics. A learner-centred curriculum should therefore not reduce personalisation to a fixed learning-style label. Instead, it should vary the learning method according to the competence, content and task.

The metacognitive results reinforce this conclusion. The most common preference for understanding and retaining complex material was to break it into smaller, simpler steps (32.4%), followed closely by taking time to reflect and internalise the material (31.5%). In terms of delivery speed, 43.5% preferred a structured pace in which each concept is clearly explained before moving to the next. For digital and social-media-based learning, 34.3% preferred videos organised into clear sequential steps, while 25.9% preferred videos incorporating interactive questions or quizzes. These findings provide direct support for the structured, short-form and interactive design adopted for the IGNITE nano-learning modules.

3.2 Empathy-informed learning design

Within IGNITE, an empathy-informed approach to learning design refers to the systematic consideration of evidence about learners’ cognitive preferences, motivations, emotional connection and preferred ways of engaging with learning content. The Empathic Questionnaire was therefore not used simply to categorise students, but to inform the design of learning resources that respond more effectively to different learner needs and preferences.

The questionnaire findings informed decisions concerning the pace, structure, visual presentation, interactivity and practical orientation of the IGNITE nano-learning modules. They also supported the

wider project approach of connecting learner preferences with personalised recommendations for further learning activities.

The strongest design implication is to combine empathy with academic rigour. Choice should concern route, pace, example or mode of engagement, while learning outcomes and quality expectations remain consistent. Learner preferences should therefore be understood as design signals rather than fixed categories that determine how an individual student must learn. This avoids both uniform instruction and unsupported assumptions that each learner has one immutable "style".

3.3 Implications for learning design

Evidence	Design response	Implementation example
47.2% prefer visual information	Use diagrams, animations and concise visual summaries	Open each topic with one explanatory visual and reuse its visual language throughout.
32.4% prefer smaller steps; 34.3% prefer sequential videos	Build explicit learning pathways	Overview → concept → worked example → practice → reflection.
43.5% prefer structured content delivery with clear explanation before progression	Use controlled pacing and clear progression between concepts	Introduce one concept at a time and make the transition to the next learning step explicit
38.9% connect through practical trial	Add authentic action	Mini-experiment, simulation, design task, or real data problem.
45.4% motivated by future relevance	State relevance early	Begin with a profession, community, or environmental challenge.
25.9% prefer interactive questions in videos	Embed retrieval and reflection	Pause-and-think prompt, poll, or one-question check.
31.5% value reflection and internalisation	Include opportunities for self-reflection and self-assessment	Short reflection prompt, pre-/post-test or progress check after a learning unit.

Overall, the Empathic Questionnaire findings provided an evidence base for the design of the IGNITE learning approach. The results supported the use of short, visually rich and clearly structured learning units combined with practical activities, interactive exercises, self-assessment and opportunities for reflection. At the same time, differences across topics and participating countries reinforced the need for a flexible multimodal approach rather than a single standardised learning format.

4. Evaluation of Nanolearning

4.1 Development process

The development of the IGNITE nanomodules followed a structured, evidence-based approach informed by the Empathic Questionnaire Report, the Nanomodules Development Plan, the common development templates, the produced video materials, and related scientific research on empathy-based learning, nanolearning, gamification and challenge-based learning.

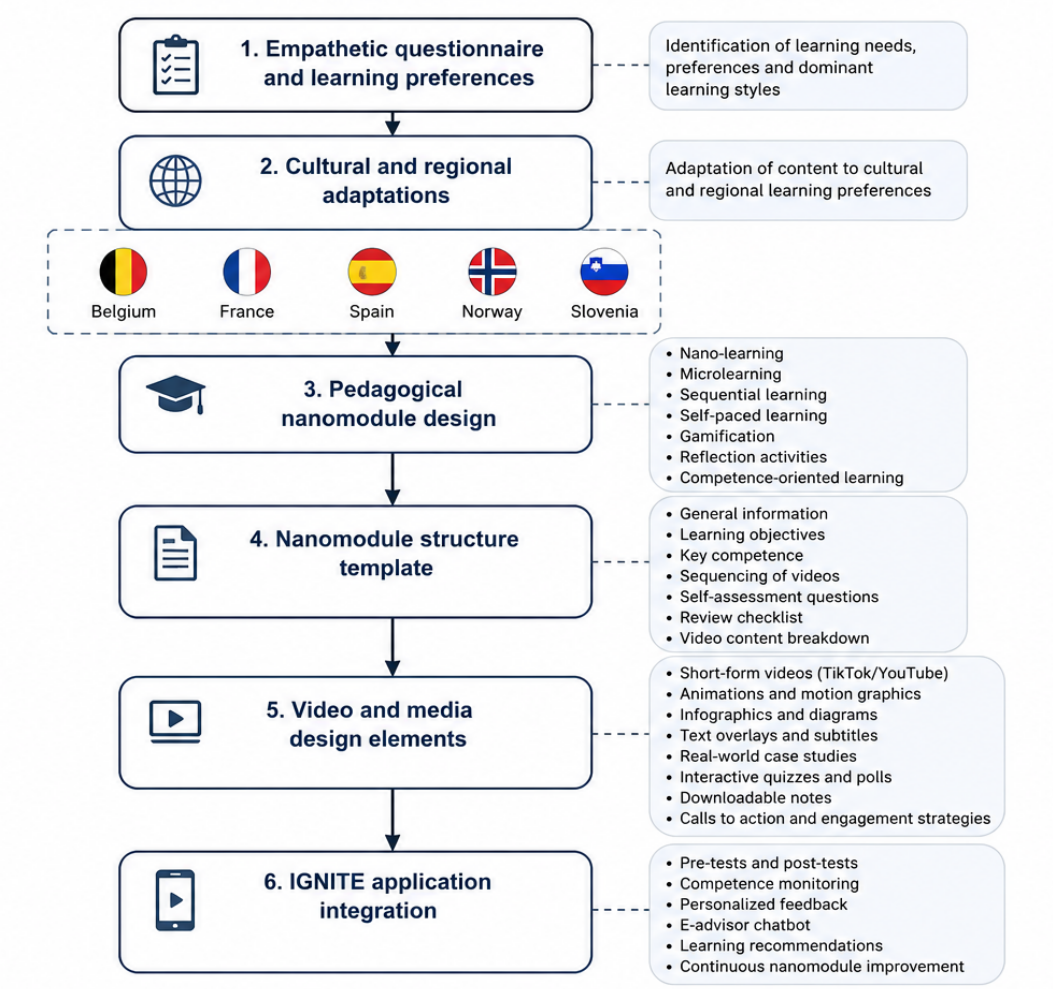
The results of the Empathic Questionnaire guided the pedagogical design of the nanomodules. As students demonstrated a strong preference for visual, practical and sequential learning, the modules were designed as short, structured video-based learning sequences. Each nanomodule consisted of one introductory video aimed at providing an accessible overview of the topic for a broader audience, followed by three to four more specialised videos presenting the topic in greater scientific and technical depth. Visual aids, concise explanations and practical examples were incorporated to support engagement, understanding and knowledge retention.

The common development plan and templates provided partners with guidance on learning objectives, content sequencing, video duration, dominant learning styles, technical specifications, interactive features and pre- and post-assessment questions. They also supported consistency across the nanomodules while allowing adaptation to different scientific disciplines and learner needs. In total, 10 nano-learning modules covering interdisciplinary topics related to sustainability, innovation and emerging technologies were developed by the participating higher education institutions.

Each nanomodule was further connected to a pre- and post-assessment in the IGNITE Competence Monitoring Application and to interactive exercises in the Virtual Learning Garden. This created a learning pathway in which students could first engage with the video-based content, practise and apply the acquired knowledge, and subsequently reflect on or monitor their learning progress.

The developed nanomodules translated this framework into accessible digital learning resources suitable for integration into STEAM programmes and online learning environments. Their concise and modular format enables flexible and self-paced learning, while their connection with gamified activities, competence monitoring and challenge-based learning supports the practical application of the acquired knowledge.



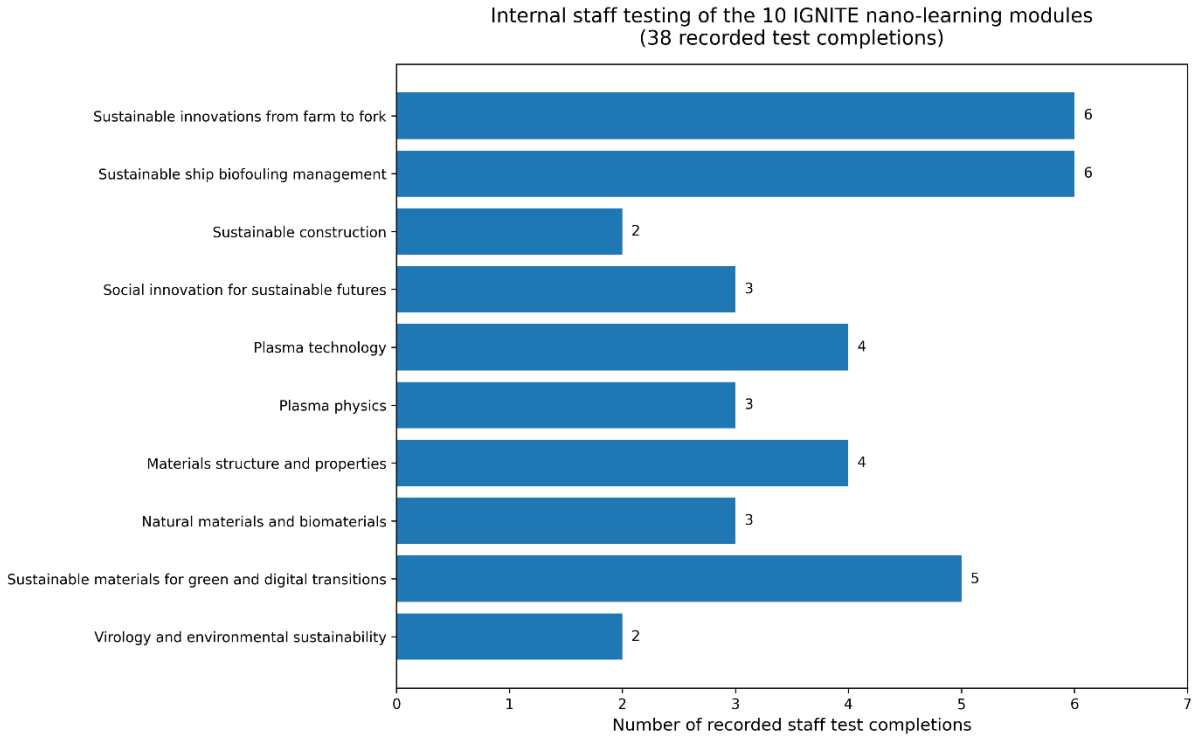


4.2 Staff evaluation

The staff evaluation included 11 respondents from the project partnership, five of whom had been directly involved in the development of the nanomodules, while six participated primarily in their evaluation. This combination provided both a developer perspective and a broader internal peer-review perspective on the quality and usability of the developed learning materials.

The internal evaluation was closely linked to the international staff training held in Larissa, Greece, in August 2025, where project staff had the opportunity to test the nano-learning approach in practice and review its pedagogical and implementation potential before wider student piloting.

The internal testing phase also involved hands-on testing of the developed nano-learning modules by project staff. The testing log recorded 38 nanomodule test completions across 13 unique tester entries. The testing was distributed across all 10 developed modules, with individual testers reviewing between one and five different nanomodules. One tester completed five modules, two testers completed four modules each, seven testers completed three modules each, one tester completed two modules, and two testers completed one module each. For each tested nanomodule, participants completed both the corresponding pre-test and post-test, enabling them to experience the learning and assessment process from the learner perspective. This broad cross-testing approach supported internal quality assurance by exposing staff to content developed by different partner institutions and across different STEAM disciplines.



Among the five developers, the prepared templates for the introductory and closing video sequences received an average score of 8.6 out of 10. The results indicate that the common templates were generally considered useful for structuring the videos and supporting a consistent project identity, while still allowing partners to adapt the production process to the specific needs of their scientific topics.

This first testing stage therefore served not only as a quality-assurance exercise but also as an initial transferability check, enabling staff to consider how the nanomodules could be integrated into their own teaching practice or recommended to colleagues.

The integration of interactive elements represented a more varied experience for developers. Ratings ranged from 1 to 5 on a five-point scale, with an average of 2.8/5. This suggests that although interactive elements could be incorporated successfully, the technical or methodological effort required differed considerably among developers. This finding supports the provision of additional practical guidance or peer support for interactive content development in future implementations.

Four of the five developers reported that they had considered different learning styles to some extent when developing their nanomodules, while one reported doing so to a great extent. All five developers reported acquiring new knowledge during the development process and improving their competences. Four reported learning and competence development to some extent and one to a great extent. All developers also considered the acquired knowledge and skills relevant to their future work, with three evaluating their future usefulness to a great extent and two to some extent.

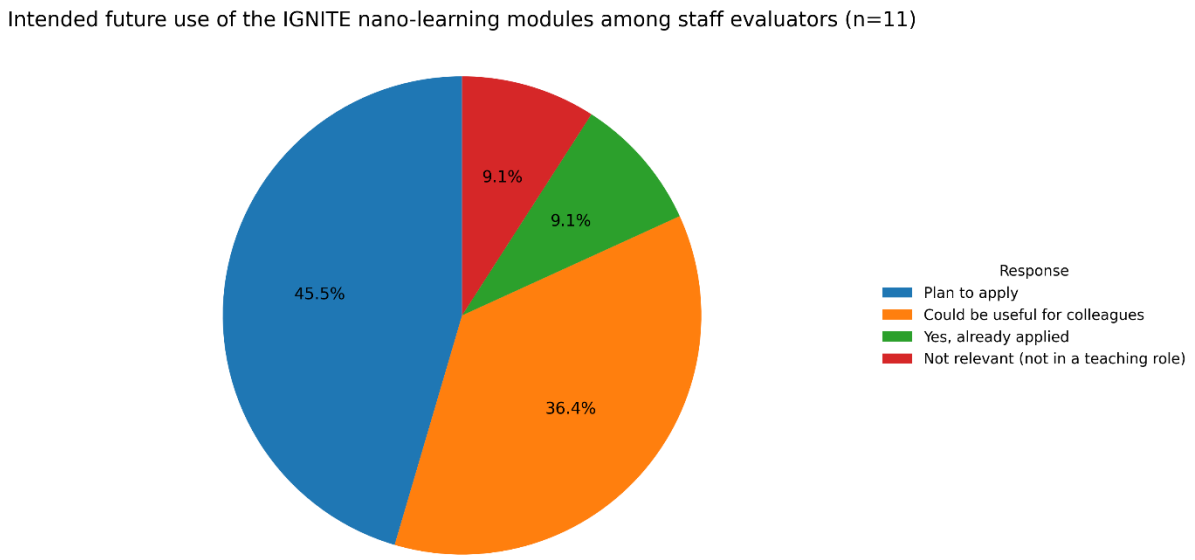
The 11 staff members/evaluators who evaluated the completed nanomodules provided predominantly positive feedback. The duration of the introductory videos was particularly well received, with eight respondents rating it as “very good”, two as “good” and one as “fair”. The duration of the professional videos received six “very good”, three “good”, one “fair” and one “poor” rating, indicating generally positive perceptions while also showing that pacing and video length may require adaptation depending on the topic.

The possibility of sharing the nanomodules through social media was another positively evaluated feature, receiving seven “very good”, two “good” and two “fair” ratings. The modular organisation of the content received five “very good”, four “good” and two “fair” ratings.

The use of pre- and post-tests for monitoring knowledge and competence development was evaluated positively by all respondents: four rated this aspect as “very good” and seven as “good”. This confirms support for integrating assessment and progress monitoring into the nano-learning approach, while later learner feedback indicates that the design and standardisation of individual assessment items can be further improved.

Seven of the 11 respondents considered subtitles in the languages of the partner institutions useful. In terms of future applicability, five respondents planned to apply the nanomodules in their own work, one reported that they had already applied them, and four considered them potentially useful for colleagues. Only one respondent indicated that this was not relevant because they were not in a teaching role.

The future-use responses further indicate strong transfer potential. Most respondents either planned to use the nanomodules themselves, had already applied them, or considered them useful for colleagues, suggesting that the developed format was perceived as a transferable educational resource rather than only as a project-specific output.



The findings confirm that the nanomodules were considered well designed, appropriately structured and suitable for digital dissemination. They also demonstrate a positive capacity-building effect among the staff involved in development and considerable potential for further institutional use. At the same time, the findings identify opportunities to strengthen support for interactive content production, ensure more consistent audiovisual quality, clarify progression between individual learning units, and further improve assessment design and feedback mechanisms.

4.3 Student evaluation

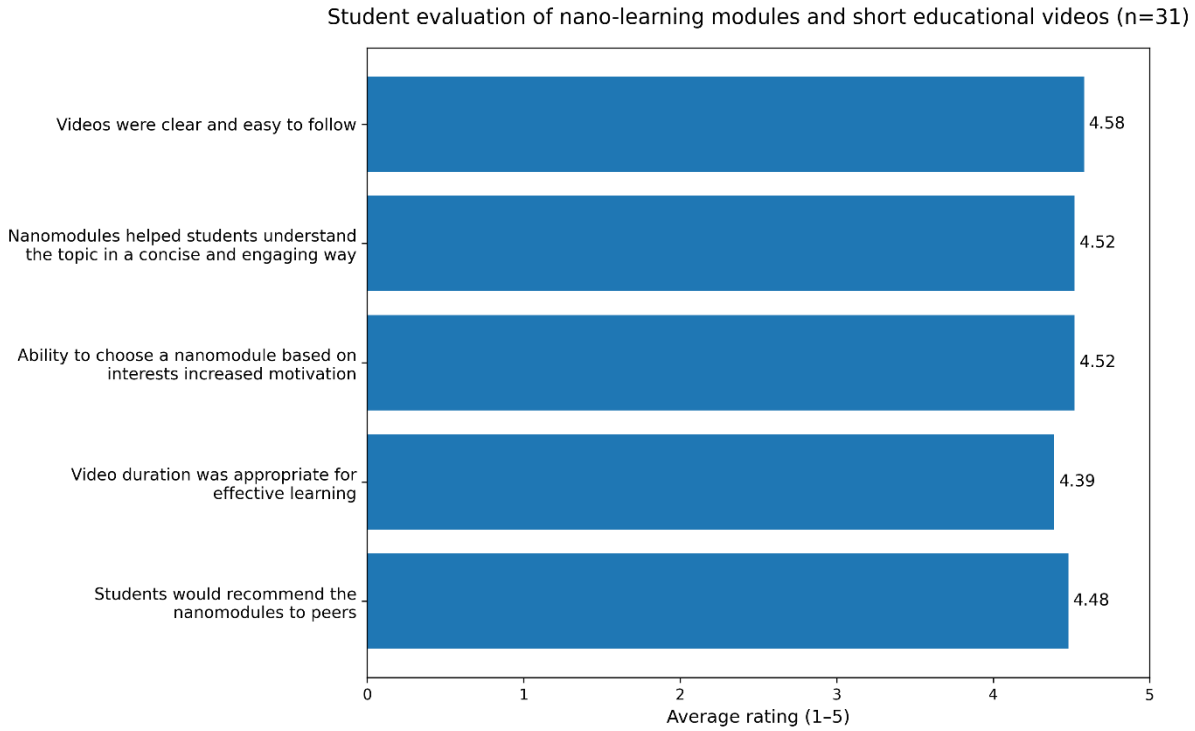
The student evaluation was conducted through the Student Virtual Workshops Evaluation Questionnaire and the reports prepared following the virtual workshops. A total of 33 questionnaire

responses were collected, of which 31 were submitted by students and two by lecturers. The analysis presented in this subsection focuses on the 31 student responses. Students represented workshops organised in Slovenia, France, Spain and Belgium.

The international virtual workshops represented the second stage of validation of the nano-learning approach, following the internal staff testing. They were used as a pilot implementation environment in which students engaged directly with the developed nanomodules, digital learning tools and related activities under facilitated learning conditions.

The evaluation examined students' perceptions of the nanomodules in terms of content clarity, relevance, structure, engagement and usefulness for understanding the addressed STEAM topics. It also considered whether the short, video-based format supported flexible and self-paced learning and whether the possibility of choosing topics according to individual interests contributed to motivation. The pilot additionally provided evidence on learner engagement, self-directed learning and the practical usability of the developed resources within an authentic workshop setting.

The student evaluation of the nanomodules was strongly positive. Across the five questionnaire items relating directly to nanomodules and videos, the average rating was 4.50 out of 5, and 93.5% of all ratings were either "agree" or "strongly agree".



Thirty of the 31 students agreed or strongly agreed that the videos were clear and easy to follow, and the same number agreed or strongly agreed that being able to choose a nanomodule according to their interests increased their motivation. Twenty-nine students positively assessed the concise and engaging presentation of the topics, while 29 also considered the video duration appropriate for effective learning. Twenty-seven students stated that they would recommend the nanomodules to their peers.

Open-ended feedback reinforced these quantitative findings. Students particularly valued the concise and accessible presentation of complex topics, the possibility of learning about subjects outside their usual field, the availability of several interdisciplinary topics, and the flexibility of video-based learning. Suggestions for further improvement included adding more practical examples and interactive

elements, improving audio clarity and subtitles where needed, offering greater depth in selected topics, and further strengthening the quality and standardisation of assessment questions.

Taken together, the quantitative ratings and qualitative comments indicate that the main design choices made during development—short duration, clarity, topic choice, visual presentation and flexible access—were successfully transferred into the student pilot phase.

The virtual workshops also provided contextual evidence concerning how the nanomodules were used in practice. Students interacted with the learning materials, completed related activities and used the project's digital tools within a facilitated learning environment. The workshops therefore functioned as a practical pilot of the integrated IGNITE learning pathway rather than as a stand-alone evaluation activity. This combination of independent nano-learning and guided workshop activity supported the wider IGNITE approach of moving from concise knowledge acquisition to interaction, practice and reflection.

The student evaluation confirms that the nanomodules were perceived as clear, engaging, appropriately concise and relevant for flexible STEAM learning. The findings are consistent with the preferences identified through the Empathic Questionnaire and provide end-user validation of the main design choices adopted during nanomodule development.

4.4 Strengths and areas for improvement

Strengths	Areas for improvement
Appropriate short-video duration and strong visual potential	Maintain flexibility in video length where additional scientific depth is required.
Positively evaluated common development and video templates	Define minimum standards for sound, narration, captioning and visual consistency.
Broad interdisciplinary topic coverage	Strengthen practical examples, authentic tasks and interactive elements.
Good social-media shareability	Create platform-specific cuts without fragmenting the curriculum.
Positive capacity-building effect for developers	Provide practical support for developing interactive content, as developer experience varied considerably.
Pre/post monitoring included by design	Improve item alignment, feedback quality and assessment validity.
Strong student acceptance: average 4.50/5 across nanomodule-related items	Further standardise quizzes and review questions for clarity, difficulty and duplication.
High potential for future institutional use reported by staff	Strengthening captions/subtitles and audiovisual accessibility where relevant.
Two-stage validation through internal staff testing and international student pilot workshops	Maintain systematic testing with both expert and end-user groups when updating or expanding the modules.

4.5 Recommendations

- Use a consistent five-part script: hook and relevance; outcome; visual explanation; application or interaction; summary and next step.
- Maintain a master version for learning management systems and produce shorter social-media derivatives from it.
- Require captions in the delivery language and prioritise partner-language subtitles for high-use modules or widening-participation contexts.
- Run technical and pedagogical peer review against a common checklist before release.
- Link every video to the previous and next learning step and display estimated completion time.
- Use quizzes for retrieval and feedback, not merely completion; explain why each answer is correct or incorrect.
- Provide developers with short practical guidance or peer-support sessions on the design and technical implementation of interactive learning elements.
- Standardise pre- and post-assessment items across modules, ensuring clear wording, appropriate difficulty, absence of duplicated questions and alignment with the intended learning outcomes.
- Maintain the concise nano-learning format while allowing selected topics to include optional deeper-learning resources for students seeking additional scientific detail.
- Retain a two-stage validation process for future nano-learning resources: internal expert review followed by pilot testing with students before wider implementation.
- Schedule periodic content review for scientific accuracy, broken links, accessibility and relevance.

5. Evaluation of the Virtual Learning Garden

5.1 Gamification approach

The Virtual Learning Garden was developed as a gamified learning environment that complements the IGNITE nanomodules and supports the continuous development of students' knowledge and competences. Its design transforms the learning pathway into a visible progression process in which learners complete online exercises and quizzes, receive feedback, and monitor their progress through the learning environment. The VLG was implemented using the LearnDash learning management system and integrated into the IGNITE project website.

All 10 IGNITE nano-learning modules were integrated into the VLG and complemented by 49 interactive exercises and challenges. The activities included multiple-choice and multiple-answer questions, matching activities, sorting and ranking exercises and other interactive tasks, enabling learners to engage with the content through different forms of knowledge retrieval and application.

The collection of online exercises provides opportunities for learners to reinforce the knowledge introduced through the nanomodules. The activities encourage active participation, knowledge retrieval, problem-solving, and the practical application of STEAM concepts. By combining short learning resources with interactive exercises, the Virtual Learning Garden supports a transition from passive content consumption to more active and reflective learning.

The gamification approach is based primarily on progress recognition, immediate feedback, and the achievement of learning milestones. The IGNITE Badge was developed as a micro-credential recognising successful completion of an individual nano-learning module. Together with progress tracking and points awarded through interactive quiz activities, it forms part of the VLG reward-based learning approach. The platform enables learners to mark learning steps as completed and monitor their overall progress, creating a visible step-by-step pathway through the learning content.

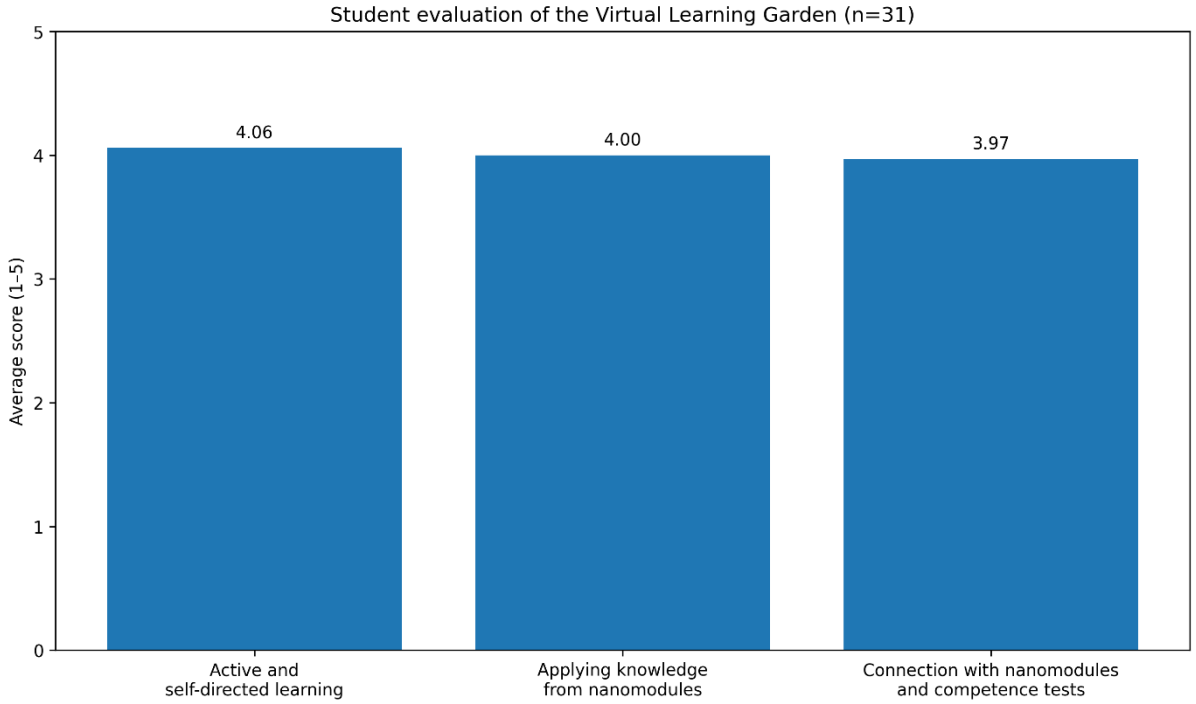
As also explored in the SDEWES 2026 conference paper, gamification can enhance engagement when it is pedagogically aligned with the learning objectives. Its effectiveness depends on whether quizzes, exercises and rewards promote meaningful learning rather than merely platform activity. The Virtual Learning Garden should therefore recognise demonstrated progress and competence development rather than only the number or speed of completed tasks.

5.2 User feedback

User feedback on the Virtual Learning Garden was collected through the Student Virtual Workshops Evaluation Questionnaire. A total of 33 responses were collected during the virtual workshop pilot phase; the analysis presented here focuses on the 31 student respondents, consistent with the student evaluation presented in Chapter 4.3.

Students evaluated three aspects of the Virtual Learning Garden: its contribution to active and self-directed learning, its usefulness for applying knowledge acquired through the nano-learning modules, and its connection with the nano-learning content and competence assessment activities in the IGNITE application.

The overall evaluation of the VLG across the three items was positive, with an average score of 4.01 out of 5. The highest-rated aspect was the contribution of VLG activities to active and self-directed learning (4.06/5). Students also positively evaluated the extent to which VLG tasks helped them apply knowledge from the nano-learning modules (4.00/5) and the connection between the VLG activities, nano-learning content and competence tests in the IGNITE application (3.97/5). Across all three items, 71.0% of student ratings were “agree” or “strongly agree”.



Open-ended responses provided additional suggestions for future refinement of the digital learning environment. Several students proposed closer integration between the VLG and the IGNITE application, including a common login and a more seamless transition between the two environments. Other suggestions concerned improved mobile usability, more intuitive navigation between learning steps and additional interactive elements. These suggestions indicate that future development should focus particularly on making the different components of the IGNITE digital ecosystem function as a more integrated learning environment.

5.3 Learning analytics

The use of the Virtual Learning Garden was monitored through anonymised learning analytics generated by the LearnDash learning management system. The analytics provide complementary evidence to the questionnaire results by showing actual participation and interaction with the learning activities. Data were extracted at the end of the project on 31 August 2026.

The VLG recorded 32 participants, exceeding the project target of 30 users. Of these, 22 users actively engaged with the integrated quizzes. A total of 63 quiz attempts were recorded, of which 47 were successfully completed, corresponding to a successful quiz-attempt rate of 74.6%.

The average achievement across all recorded quiz attempts was 80.3%, while individual quiz achievements reached up to 100%. These results provide evidence that users did not only access the learning environment but actively interacted with its assessment activities and demonstrated knowledge related to the nano-learning content.

Indicator	Achieved value
Participants recorded in the VLG	**32**
Recorded quiz attempts	**63**
Successfully completed quiz attempts	**47**
Successful quiz-attempt rate	**74.6%**
Average quiz achievement	**80.3%**
Highest recorded quiz achievement	**100%**

The combination of questionnaire results and platform analytics therefore provides complementary evidence of both perceived educational value and actual use of the VLG. Student feedback indicates that the environment supported active and self-directed learning, while the analytics demonstrate participation, repeated interaction with quizzes and generally high quiz achievement.

Both main quantitative indicators associated with the Virtual Learning Garden were exceeded. The project developed 49 confirmed interactive exercises compared with the target of 25, while 32 participants were recorded in the VLG compared with the target of 30 users.

5.4 Strengths and areas for improvement

Strengths	Areas for improvement
All 10 nano-learning modules integrated into one structured learning environment	Further strengthen seamless navigation between VLG, IGNITE application and other digital tools
49 interactive exercises using several activity formats	Continue reviewing quiz clarity, difficulty and feedback quality
Visible progress monitoring and structured learning pathways	Consider a common login / single-sign-on approach for the VLG and IGNITE application
Gamified recognition through points, progress tracking and the IGNITE Badge	Ensure badge criteria remain transparent and clearly linked to completion requirements
Positive student evaluation of VLG activities (overall average 4.01/5)	Continue improving mobile usability and accessibility
32 participants, exceeding the target of 30 VLG users	Further streamline progression between completed lessons and subsequent activities
63 quiz attempts with an average achievement of 80.3%	Continue monitoring learning analytics to support evidence-based improvements
Flexible and self-paced access	Add further interactive and practical elements where pedagogically appropriate
Integration with the wider IGNITE learning pathway	Maintain transparent information about the use of learning data

5.5 Recommendations

Based on the available evidence, the following recommendations are proposed:

- Align every exercise, quiz and badge with a clearly defined learning outcome or competence.
- Use badges to recognise demonstrated achievement or successful completion based on transparent criteria, rather than participation alone.
- Provide immediate and explanatory feedback after quiz responses, including links to relevant nanomodule content.
- Organise the Virtual Learning Garden into visible learning pathways with clear starting points, progression stages and completion requirements.
- Combine individual progress recognition with collaborative activities where appropriate, avoiding excessive competition or public ranking.
- Allow learners to review completed activities, monitor their progress and identify recommended next steps.
- Strengthen technical integration between the Virtual Learning Garden and the IGNITE Competence Monitoring Application, ideally through a common user account or single-sign-on approach.
- Optimise the VLG for mobile devices and ensure consistent usability across different screen sizes and devices.
- Where possible, automate progression to the next learning activity after completion of a lesson or quiz to create a smoother learning pathway.
- Continue expanding interactive and practical activities while maintaining a clear connection with the corresponding nano-learning content.
- Test keyboard navigation, colour contrast, captions and screen-reader compatibility.
- Use the established LearnDash analytics periodically to monitor participation, quiz engagement and achievement and to inform future revisions of the learning activities.
- Protect learner privacy by using aggregated or anonymised data for evaluation and by providing transparent information about data collection and retention.
- Integrate the Virtual Learning Garden into formal STEAM courses and workshop activities so that its exercises and badges contribute meaningfully to the overall learning experience.

6. Evaluation of the IGNITE Competence Monitoring Application

6.1 Competence monitoring

The IGNITE Competence Monitoring Application was developed as a digital self-assessment and learning-support tool that enables users to monitor the development of their knowledge and competences. Based on the application video manual and the development documentation prepared by MPŠ, the application connects the project's nanomodules, assessment activities and personalised learning recommendations within a single digital environment. The application was designed as part of the wider IGNITE learning pathway, linking knowledge acquisition through nano-learning with assessment, progress monitoring and recommendations for further competence development.

Registered users complete a pre-test before engaging with a nanomodule and a corresponding post-test after completing the learning content and associated activities. The pre-/post-assessment approach is intended to support comparison of learning outcomes and to make changes in knowledge and competence development visible to learners. This process promotes self-reflection and makes competence development more visible.

The application also provides information about users' progress and can recommend additional learning opportunities, including related nanomodules, workshops, webinars and other educational resources. The integrated e-advisor extends this function by supporting personalised recommendations for further learning and competence development based on the learner's profile and progress. In this way, it supports the continuity of the learning process beyond the completion of an individual activity.

The educational value of the application depends not only on its technical functionality but also on the quality of the underlying competence framework and assessment questions. Each pre- and post-test should therefore be aligned with the corresponding learning objectives and measure the knowledge or competence addressed by the nanomodule.

6.2 User experience

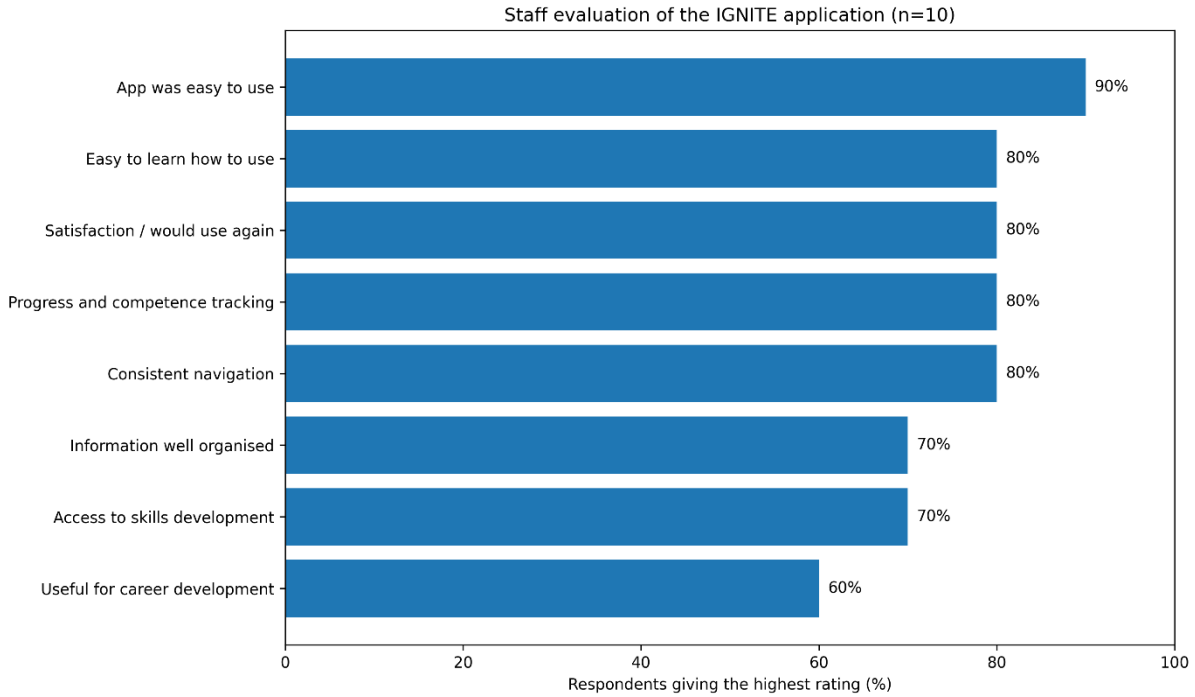
User experience was evaluated through the Online Application and Staff Training Evaluation Report and the Student Workshop Questionnaire. The available staff evaluation, based on responses from ten participants, indicates a highly positive assessment of the application's usability, organisation and usefulness. The student workshop evaluation provides an additional end-user perspective based on 31 student responses, allowing the application to be assessed both by project staff and by learners using the tool during pilot workshops.

Nine respondents rated the application's ease of use with the highest score, while eight gave the highest rating to the ease of learning how to use it. Seven respondents strongly agreed that the interface and graphic design were satisfactory. In addition, seven respondents strongly disagreed that the application was unnecessarily complex, indicating that most participants found it intuitive and manageable.

The organisation and presentation of information were also positively evaluated. Seven respondents gave the highest score to the clarity and accessibility of the information, while eight strongly agreed that navigation between screens was consistent. Seven respondents considered the application's functions accessible and sufficient for their user level.

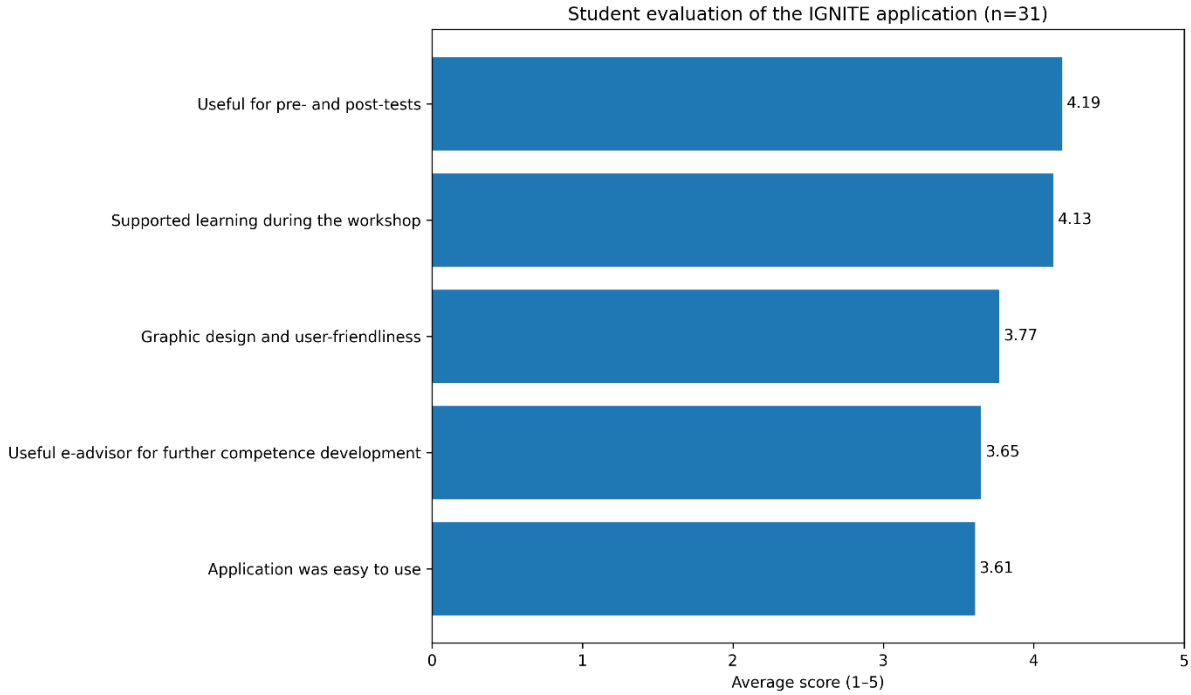
Progress monitoring was one of the application's most highly valued features. Eight respondents gave the highest score to the information provided about competence development and to the ability to track learning activities and conduct self-assessment. This indicates that users understood the purpose of the application and recognised its value as a learning-support tool rather than merely a technical platform.

Overall satisfaction was also high. Eight respondents strongly agreed that they were satisfied with the application and would use it again. Seven respondents considered that it improved access to skills development, while six gave the highest score to its potential usefulness for career development.



Student feedback provided a somewhat more differentiated but still positive picture of the application. Across five application-related items, the average student rating was 3.87 out of 5. The highest-rated aspect was the usefulness of the application for completing the pre- and post-tests of competences (4.19/5), followed by its contribution to learning during the workshop (4.13/5). The graphic design and user-friendliness received an average score of 3.77/5, while ease of use was rated 3.61/5. The usefulness of the e-advisor for supporting further competence development received an average rating of 3.65/5. Overall, 69.0% of all student ratings across the five application-related items were either "agree" or "strongly agree".

The student results confirm the educational usefulness of the application, particularly in relation to assessment and learning support, while also identifying usability and interface-related aspects that can be improved. This difference between the very positive staff evaluation and the more moderate student ratings is valuable, as it suggests that users with less familiarity with the application may require a more streamlined interface and clearer initial guidance.



Open-ended student feedback identified several recurring improvement priorities. These included closer technical integration between the IGNITE application and the Virtual Learning Garden, preferably through a common login; simpler onboarding and clearer guidance for first-time users; improved mobile usability; refinement of the visual interface; and further standardisation of pre- and post-test questions. Several respondents also reported login-related difficulties, reinforcing the importance of testing account creation and authentication across different user profiles and devices.

6.3 Results of competence assessment

The IGNITE competence monitoring application was used to support pre- and post-assessment of learning progress across all ten nano-learning modules. Before engaging with a selected nanomodule, users could complete a pre-assessment, while the corresponding post-assessment enabled them to review their performance after completing the learning content and related activities. The assessment functionality therefore provided a practical mechanism for monitoring changes in knowledge and supporting learner reflection.

A total of 60 users registered in the IGNITE application during project implementation, exceeding the project target of 30 users. Based on the available assessment graphs, 44 unique user IDs actively engaged with at least one nano-learning module assessment. Across the ten modules, 70 module-level participations were recorded, showing that several users engaged with more than one nanomodule. The number of active users therefore differs from the number of registrations and from the total number of module-level participations.

The distribution of active users across the ten nano-learning modules was as follows:

Nano-learning module	Active users
Sustainable innovations from farm to fork	8
Sustainable ship biofouling management	4
Sustainable construction	5
Social innovation for sustainable futures	6
Plasma physics	5
Plasma technology	4
Materials structure and properties	6
Natural materials and biomaterials	15
Sustainable materials for green and digital transition	9
Virology and environmental sustainability	8
Total module-level participations	**70**

The highest level of participation was recorded for Natural Materials and Biomaterials, followed by Sustainable Materials for Green and Digital Transition. Participation was nevertheless recorded across all ten nanomodules, demonstrating that the assessment functionality was used across the full thematic range of the IGNITE learning offer.

The application generated graphical comparisons of before and after assessment values on a 0–100 scale. The available results show a number of cases in which post-assessment scores were higher than the corresponding pre-assessment scores, indicating positive learning progress following engagement with the nano-learning content. In several cases, users reached post-assessment scores of 100, while other paired observations also show improvements between the two assessment points.

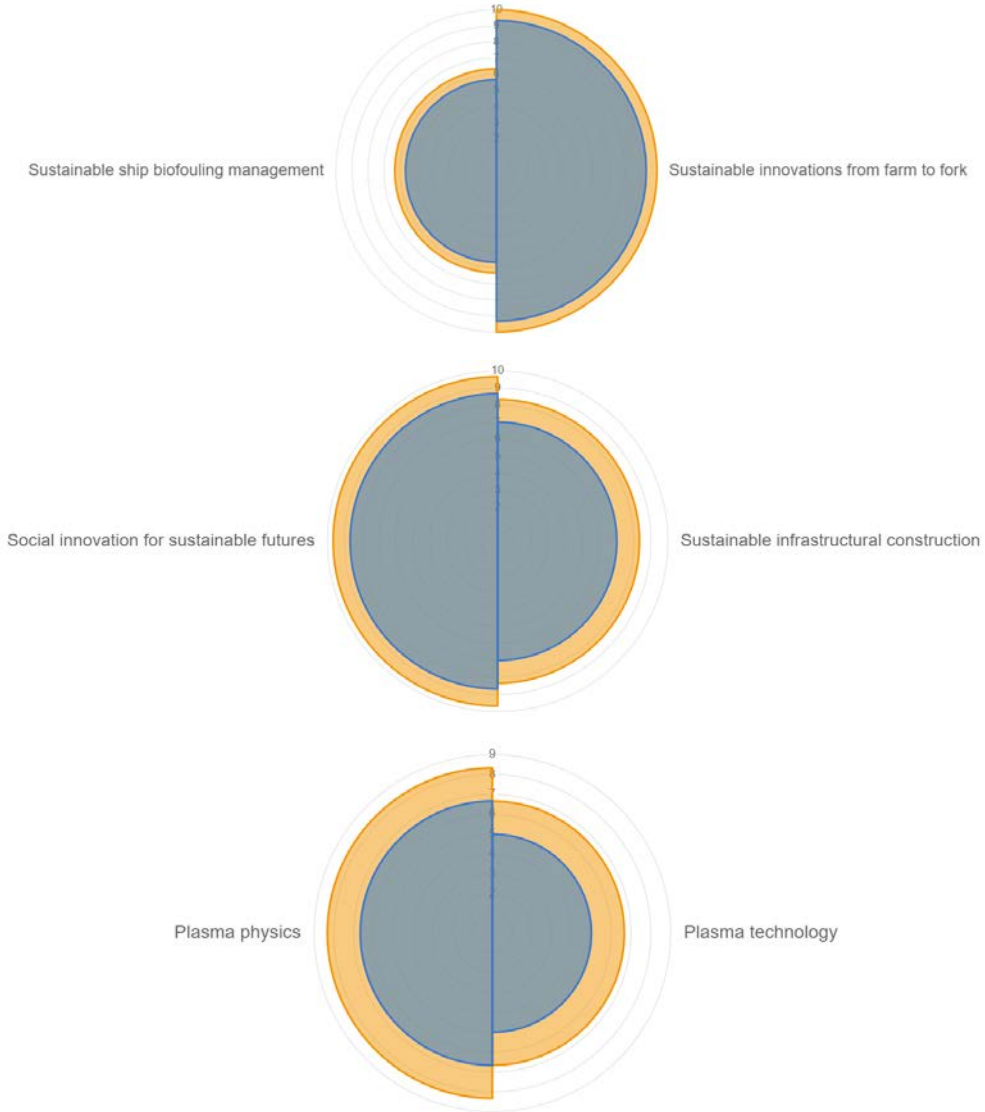
At the same time, the available graphical outputs should be interpreted cautiously. Some user IDs contain only a pre-assessment or only a post-assessment value, while zero values cannot be reliably distinguished from missing or incomplete assessments based on the graphical output alone. For this reason, the current analysis does not calculate an overall average learning gain or statistical significance across all users. Only clearly visible paired results can be interpreted as evidence of individual progress.

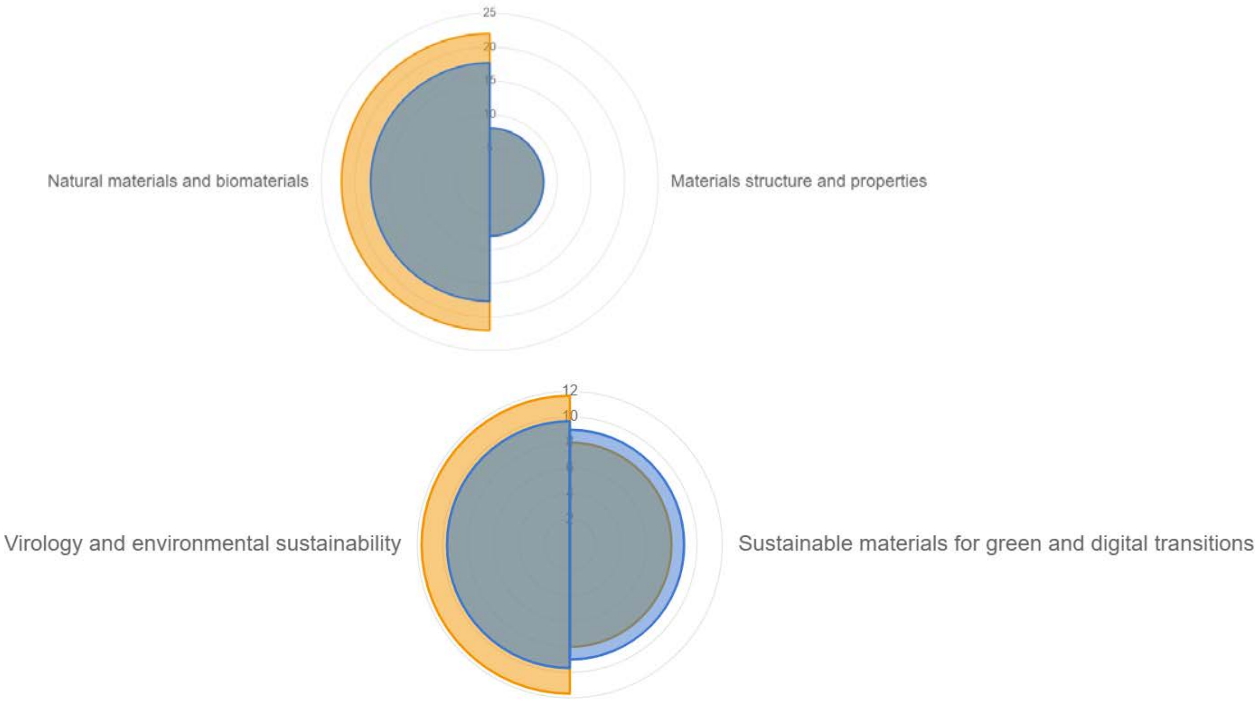
The assessment data nevertheless demonstrate that the pre-/post-assessment functionality was operational and actively used within the IGNITE learning pathway. The results complement the user-evaluation findings presented in Chapter 6.2, where both staff and students positively evaluated the usefulness of the application for self-assessment, progress monitoring and learning support.

The distinction between registered and active users is important for interpreting the results. While 60 accounts were registered, the available assessment data indicate 44 unique active user IDs that engaged with at least one assessment activity. The total of 70 module-level participations further indicates repeated use by some learners across several nano-learning modules. This provides evidence

not only of initial uptake of the application but also of repeated engagement with its competence-monitoring functionality.

Overall, the results confirm that the IGNITE Competence Monitoring Application fulfilled its intended role as a digital tool for supporting assessment, self-reflection and monitoring of learning progress. The application was used across all ten nano-learning modules, exceeded the planned target for registered users, and generated pre- and post-assessment evidence indicating learning progress for a number of participants. Future development should further strengthen the export and reporting functionality so that paired pre-/post-assessment data, completion rates and aggregate learning gains can be analysed automatically and consistently.





6.4 Strengths and areas for improvement

Confirmed strength	Improvement priority
High perceived ease of use and low complexity	Further simplify onboarding for first-time and student users.
Strong information architecture and navigation consistency	Conduct accessibility testing with assistive technologies and low-confidence users.
Progress tracking and self-assessment highly valued, with pre-/post-assessment results indicating learning progress for several users	Strengthen paired pre-/post-analysis and explain the evidence behind scores and recommended next steps.
Pre-/post-assessment functionality highly valued by students (4.19/5)	Further standardise test items and ensure comparability between pre- and post-assessment.
Application supported student learning during pilot workshops (4.13/5)	Strengthen integration with the VLG and other IGNITE learning components.
High willingness to use again	Integrate use into an authentic course workflow rather than leave it optional.
Positive perceived skills-development value	Connect competences to observable tasks, portfolios and career examples.
Functional e-advisor for further competence development	Clarify how recommendations are generated and improve their visibility and relevance for learners.

Assessment functionality actively used across all 10 nano-learning modules, with 44 unique active users and 70 module-level participations	Introduce automated reporting of unique active users, completed pre-/post-assessment pairs and module-level participation.
High user uptake: 60 registered users, exceeding the target of 30	Distinguish clearly between registered, active and assessment-completing users in future analytics.

6.5 Recommendations

- Publish a concise competence framework with definitions, levels and evidence examples.
- Align each assessment item to one outcome and review item difficulty and ambiguity.
- Use self-assessment as reflection, not as the sole proof of competence.
- Add exportable learner summaries that can support advising or portfolio reflection with explicit consent.
- Explain data collection, retention, access, and deletion in plain language.
- Provide a short onboarding walkthrough for first-time users.
- Strengthen integration between the IGNITE application and the Virtual Learning Garden, ideally through a common login and more seamless navigation between the two environments.
- Optimise the application for mobile devices and test usability across different screen sizes and operating systems.
- Standardise pre- and post-assessment questions and regularly review them for clarity, duplication, alignment with learning outcomes and appropriate difficulty.
- Make the purpose and logic of the e-advisor transparent to learners and clearly explain how recommendations relate to their competence profile and learning progress.
- Use application analytics to periodically review registered and active users, assessment completion rates, repeated engagement, pre-/post-assessment progress and competence-development patterns, and use the findings to continuously refine the tool.
- Enable automated export of anonymised paired pre- and post-assessment data so that learning gains can be calculated at individual, nanomodule and overall level.
- Clearly distinguish between registered users, active users, completed assessments and module-level participations in future monitoring dashboards.
- Define how missing, incomplete and zero assessment values are recorded in the system to avoid ambiguity in the interpretation of learning analytics.

7. Evaluation of the Innovation Marathon

7.1 Learning concept

The IGNITE Innovation Marathon was designed as a four-month challenge-based learning activity in which students from the partner higher education institutions developed sustainability-oriented projects addressing concrete environmental or societal challenges. The activity connected the theoretical and digital components of IGNITE with practical application. Students were expected to apply knowledge acquired through the nanomodules, work independently or in teams, communicate regularly with mentors, and present their solutions to an international audience. Within the wider IGNITE learning pathway, the Innovation Marathon represented the “Apply” stage, following the “Learn” stage supported by the nanomodules and the “Practice” stage provided through the Virtual Learning Garden. In this way, students progressed from acquiring knowledge and practising new skills to applying them to authentic sustainability-oriented challenges.

Its objectives were:

- To promote hands-on learning and the practical application of knowledge acquired through the IGNITE nanomodules.
- To strengthen sustainability, innovation, entrepreneurship, problem-solving and transversal competences.
- To encourage interdisciplinary collaboration among students from engineering, environmental sciences, materials science, sensor technologies and innovation-related disciplines.
- To strengthen cooperation between higher education, research and industry through mentoring and project co-creation.
- To support students in developing solutions to authentic environmental and societal challenges.
- To produce the Scrapbook of Sustainable Student Innovation Projects, showcasing the developed student projects and their links to the IGNITE learning content and sustainability challenges.

The guidelines established initial project indicators of at least five student projects, ten participating students, and five mentors. Partner HEIs were expected to recruit at least two students and provide at least one mentor. Mentoring meetings were recommended every two weeks, complemented by consortium-level progress monitoring.

7.2 Challenge-based learning process

The Innovation Marathon followed a structured pathway from topic selection to final presentation and evaluation, followed by the documentation of the student projects in the final Scrapbook.

Preparation phase

During the initial phase, the consortium agreed on the organisational rules, common project and presentation templates, mentoring arrangements, evaluation procedure and general structure of the activity. Project topics were selected from areas addressed by the IGNITE nanomodules, ensuring continuity between digital learning and practical application. Partner institutions recruited students,

appointed mentors and designated representatives for the evaluation committee. Institutions were also encouraged to integrate the activity into existing course requirements wherever possible.

Project-development phase

From January to April 2026, students developed their projects individually or in teams. The guidelines recommended regular meetings with mentors and periodic progress checks at consortium level.

Mentors supported students in:

- Defining a manageable challenge and project scope.
- Selecting an appropriate methodology.
- Linking their work to sustainability principles.
- Applying relevant knowledge from the nanomodules.
- Accessing laboratories, data, materials or specialist expertise.
- Reviewing project feasibility and potential impact.
- Preparing the final report and presentation.

Students were encouraged to maintain a project logbook documenting their progress, difficulties, decisions and learning. This reflective element is important in challenge-based learning because it provides evidence of the development process rather than focusing exclusively on the final solution.

Final presentation and evaluation

The projects were presented during the final Innovation Marathon event at UPC Barcelona on 7-8 May 2026. Presentations could be delivered onsite or online, enabling participation across the partner institutions. An international evaluation committee assessed the submitted projects using the common evaluation framework, provided feedback and selected the winning project. Following the final event and evaluation, the project summaries, student and mentor information, links to the relevant IGNITE nanomodules and visual materials were consolidated into the final Scrapbook of Sustainable Student Innovation Projects.



7.3 Evaluation framework

The Innovation Marathon evaluation framework used by the international evaluation committee had a maximum score of 100 points:

Evaluation criterion	Maximum score
Relevance of the environmental challenge	20
Quality of the methodology	20
Level of innovation	20
Feasibility and potential impact	20
Quality of the presentation and report	10
Teamwork and communication	10
Total	**100**

The same evaluation framework was applied to the student projects presented at the final Innovation Marathon event, providing a common basis for comparing projects across different scientific and disciplinary fields. The international evaluation panel assessed the projects following the student presentations and used the resulting scores and feedback to support the final selection of the winning project. The final Scrapbook also documents these six evaluation criteria as the common basis for project assessment.

The weighting placed greater emphasis on the substance of the projects than on presentation. Environmental relevance, methodology, innovation, feasibility and potential impact accounted for 80% of the total score, while presentation, teamwork and communication accounted for the remaining 20%. This structure ensured that scientific and practical quality, sustainability relevance, innovation and implementation potential remained central to the assessment, while communication and collaboration were also recognised as important transversal competences.

For future editions, the consistency and transparency of the evaluation could be further strengthened by supplementing the criteria with anchored performance descriptors defining, for example, excellent, good, satisfactory and insufficient performance. A short calibration exercise among evaluators before scoring could also help ensure more consistent interpretation of the criteria across disciplinary backgrounds.

7.4 Participant evaluation results

Participant feedback was collected through the IGNITE Innovation Marathon Evaluation Questionnaire following the implementation of the Innovation Marathon. The questionnaire covered the main dimensions foreseen in the evaluation framework, including organisation, mentoring and collaboration, competence development, sustainability-related motivation, overall learning experience, and evaluation of the final event.

A total of six participants completed the questionnaire: two students, three professors/mentors and one participant from another stakeholder category. All six respondents had participated in the Innovation Marathon Final Event in Barcelona. Given the relatively small number of responses, the findings should be interpreted as indicative evidence of participant experience rather than as a representative assessment of all Innovation Marathon participants.

The overall evaluation of the Innovation Marathon was highly positive. Across the ten core evaluation statements, the average rating was 4.38/5, while the overall experience with the Innovation Marathon was rated 4.50/5.

Evaluation item	Average score (/5)
The Innovation Marathon was well organised	4.50
Project guidelines and templates provided sufficient support	4.83
Encouraged creativity and innovative thinking	4.17
Collaboration between students and mentors was effective	4.50
Mentoring support was helpful	4.67
Supported development of skills useful for future studies or careers	4.33
Strengthened teamwork and interdisciplinary collaboration skills	4.17
Innovation Marathon is a valuable learning method for higher education	4.33
Increased motivation to work on sustainability challenges	4.00
Would recommend participation in a similar Innovation Marathon	4.33
Overall experience with the Innovation Marathon	4.50

The strongest result concerned the project guidelines and templates (4.83/5), indicating that the common structure provided effective support for developing the projects and preparing the final presentations. Mentoring support was also rated very highly (4.67/5), while both the overall organisation of the Innovation Marathon and the effectiveness of collaboration between students and mentors received 4.50/5. These findings support the value of combining a common project framework with regular academic mentoring.

Participants also perceived the Innovation Marathon as contributing to competence development. The usefulness of the acquired skills for future studies or careers and the value of the Innovation Marathon as a higher-education learning method were both rated 4.33/5. Creativity and innovative thinking and teamwork and interdisciplinary collaboration both received 4.17/5. The lowest-rated core item was increased motivation to work on sustainability challenges (4.00/5), although this still represents a positive assessment.

The Final Innovation Marathon Event in Barcelona was evaluated separately by six respondents. Student project presentations received the highest score (4.83/5), while overall satisfaction with the organisation and outcomes of the event was rated 4.50/5.

The results indicate particularly strong appreciation of the student presentations and the overall outcomes of the final event. Feedback from the evaluation committee was also positively assessed (4.33/5). Networking opportunities received the lowest score within the final-event evaluation (3.83/5), suggesting that future editions could provide more structured opportunities for interaction and exchange between participating teams, mentors and external stakeholders.

Open-ended responses complement the quantitative findings. Participants particularly valued the opportunity to learn from other student projects, collaboration among participants, interdisciplinary learning, networking, and the focus on sustainability and green innovation. Students specifically highlighted the opportunity to share their own work, learn from projects developed by others and strengthen interdisciplinary skills.

Suggestions for future editions included stronger promotion and dissemination of the Innovation Marathon through social media and LinkedIn, as well as dedicated feedback and exchange sessions between project teams. Such sessions could enable students to discuss their approaches, exchange ideas and receive additional peer feedback beyond the formal jury evaluation.

The participant evaluation provides positive evidence for the educational value of the Innovation Marathon. The combination of common project guidelines, mentoring, interdisciplinary project development and an international final event was positively perceived, while the results also identify opportunities to strengthen sustainability-related motivation, networking and structured peer-to-peer exchange in future implementations.

7.5 Jury evaluation and project results

A total of eight student projects were presented and assessed during the final Innovation Marathon. The international evaluation committee consisted of seven evaluators representing seven project partners. The common 100-point evaluation framework described in Section 7.3 was used to assess the projects.

The available project records identify Vittoria Rogge's project from UPC as the winning project. In the final Scrapbook, the project is presented as PlasmaCure – Plasma-Based Biomaterials for Localized Therapy. The winning project achieved the highest average jury score, 86.29/100. It was followed by MagNetZero – Magnetic MOFs for Energy-Efficient Carbon Capture with 84.14/100 and Waste2Cup – Transforming Food Waste into Home Compostable Cups with 82.00/100. The results indicate that the highest-rated projects combined clear sustainability relevance with methodological quality, innovation potential and a credible pathway towards practical impact.

The winning project demonstrates the interdisciplinary ambition of the Innovation Marathon by connecting plasma technology, advanced materials, biomedical applications, and societal relevance. It also illustrates the potential of the IGNITE approach to encourage students to translate advanced scientific knowledge into an innovative application addressing a significant health-related challenge.

More broadly, the jury results demonstrate that the Innovation Marathon generated a diverse portfolio of student solutions spanning sustainable agriculture, carbon capture, environmental monitoring, biomaterials, circular packaging, sustainable mobility and plasma-based biomedical applications. The final portfolio therefore went beyond a single disciplinary area and demonstrated the transferability of the IGNITE challenge-based learning approach across different STEAM contexts. The final Scrapbook documents all eight projects and their links to the relevant IGNITE nanomodules.

7.6 Scrapbook of sustainable student innovation projects

The final Scrapbook of Sustainable Student Innovation Projects was developed as a tangible and transferable output of the IGNITE Innovation Marathon. Its purpose was to document the student solutions developed during the challenge-based learning process and to demonstrate how knowledge acquired through the IGNITE nanomodules could be translated into practical sustainability-oriented applications. The Scrapbook therefore serves both as a record of the Innovation Marathon and as an example of how the IGNITE learning pathway can progress from learning, through practice, to application.

The Scrapbook presents eight student innovation projects, exceeding the initial project target of at least five projects. For each project, it provides a concise description of the project focus, the student authors, the mentor or mentoring team, the participating institution and the corresponding IGNITE nanomodule. This structure makes the connection between the learning content and the student-developed solutions explicit.

The portfolio demonstrates the interdisciplinary character of the Innovation Marathon, with projects addressing agriculture, climate mitigation, environmental monitoring, biomedical applications, circular materials, sustainable mobility and plasma-based technologies. The range of project topics also shows that the challenge-based learning approach could be applied across different STEAM disciplines and institutional contexts.

Beyond presenting the projects themselves, the Scrapbook highlights the competences that the Innovation Marathon aimed to strengthen, including sustainability, innovation, entrepreneurship, teamwork, problem-solving, interdisciplinary collaboration and communication. These competences reflect the broader IGNITE objective of supporting students not only in acquiring knowledge, but also in using that knowledge to develop and communicate solutions to real-world challenges.

The Scrapbook also documents the common project-evaluation approach used during the final Innovation Marathon event. It presents the six evaluation criteria applied by the international jury: relevance of the environmental challenge, quality of the methodology, level of innovation, feasibility and potential impact, quality of the presentation and report, and teamwork and communication. In this way, the publication links the presentation of student outputs with the quality criteria used to assess them.

From a dissemination and transferability perspective, the Scrapbook provides a concise and visually accessible overview of the Innovation Marathon outcomes. It can be used by educators, students and other higher-education institutions as inspiration for future challenge-based learning activities, while the documented projects provide concrete examples of how nanolearning content can be extended into mentored, interdisciplinary and application-oriented student work.

The Scrapbook provides evidence that the Innovation Marathon moved beyond the development of isolated student assignments and generated a portfolio of eight sustainability-oriented innovation projects connected to the IGNITE learning ecosystem. It therefore represents both a project result and a reusable educational resource that can support future implementation of challenge-based learning in STEAM higher education.

7.7 Strengths and areas for improvement

Strengths	Areas for improvement
Strong connection between nanomodules and practical application, demonstrated in the final Scrapbook, where all eight projects are explicitly linked to relevant IGNITE nanomodules	Document more explicitly how specific knowledge, methods or concepts from the nanomodules informed project decisions, methods and outcomes.
Authentic environmental, technological and societal challenges across a diverse portfolio of eight student projects	Confirm project feasibility and scope at an early stage.
Demonstrated interdisciplinary and international learning experience	Design cross-institutional teamwork intentionally and provide suitable collaboration tools.
Highly valued mentoring support (4.67/5) and effective collaboration between students and mentors (4.50/5)	Define minimum contact frequency, response expectations and mentor responsibilities.
Common project-report and presentation templates were highly valued by participants (4.83/5)	Introduce compulsory milestone reviews and minimum evidence requirements.
Common 100-point evaluation framework enabled structured comparison of eight projects by an international evaluation committee	Develop anchored performance descriptors, calibrate evaluators before scoring, and define a clear procedure for handling missing evaluator scores.
Student project presentations at the international final event were highly rated (4.83/5)	Create more structured networking and peer-feedback opportunities; networking was the lowest-rated element of the final event (3.83/5).
Participants reported positive competence development, including skills relevant to future studies or careers (4.33/5) and teamwork and interdisciplinary collaboration (4.17/5)	Introduce a consistent reflection framework linked to the IGNITE competences.
Final Scrapbook creates a transferable project legacy by documenting all eight projects, their focus, authors, mentors and links to the IGNITE nanomodules	In future editions, extend the Scrapbook with project implementation pathways, follow-up developments and lessons learned.
Transparent jury evaluation and selection of a winning project provided recognition and visibility for high-quality student work	Ensure that all teams receive detailed developmental feedback, not only a final score.
Strong overall participant satisfaction with the Innovation Marathon (4.50/5) and positive	Strengthen sustainability-related motivation and provide more opportunities for

Strengths	Areas for improvement
perception of its value as a higher-education learning method (4.33/5)	structured exchange between participating teams.

7.8 Recommendations

- Integrate the Innovation Marathon into formal courses or award academic recognition wherever institutional regulations permit.
- Use a staged process consisting of challenge definition, evidence review, concept selection, project planning, prototype or model development, testing, impact assessment and final presentation, with clearly defined milestone reviews during project development.
- Establish minimum mentoring standards, including recommended meeting frequency, expected response times and procedures for addressing delays or team difficulties.
- Provide mentors with guidance on coaching, inclusive teamwork, constructive feedback and the boundaries between mentoring and completing work on behalf of students.
- Facilitate cross-institutional teams through common communication channels, shared working spaces and clearly defined roles, and provide structured opportunities for peer exchange between participating teams.
- Use at least two evaluators for each project and retain criterion-level scores and written comments. Supplement the scoring rubric with anchored performance descriptors and agree in advance how missing evaluator scores will be handled when calculating final results.
- Introduce a short evaluator calibration session before the final scoring to support consistent interpretation of the assessment criteria across disciplines.
- Provide all participating teams with structured developmental feedback, including both jury comments and opportunities for peer feedback, rather than relying only on the final numerical score or winner selection.
- Strengthen networking opportunities during the final event through dedicated networking sessions, facilitated project exchanges or thematic discussion groups.
- Strengthen communication and dissemination of the Innovation Marathon before and during implementation, including the use of professional and social-media channels to increase visibility and attract students, mentors and external stakeholders.
- Conduct a short follow-up evaluation after three to six months to determine whether projects continued, developed prototypes, entered competitions or established external collaborations.
- Use the Scrapbook not only as a collection of final projects but also as a learning resource documenting methodology, challenges, lessons learned and recommendations, and where possible add follow-up information on project continuation, implementation or further development.
- Collect participant feedback systematically from students, mentors and evaluators after each future Innovation Marathon and use the results to refine mentoring, networking, assessment and organisational arrangements.

8. Evaluation of the Staff Training

8.1 Training design and participation

The IGNITE staff training was organised in Larissa, Greece, on 27–28 August 2025. The activity was organised by Innovation Hive as the lead partner for R3.3 Staff Training and Learning Mobility within WP3. It was designed as a capacity-building and internal testing activity that introduced project partners to the IGNITE digital learning ecosystem and prepared them to use, evaluate and further develop the project outputs.

The programme combined theoretical orientation with demonstrations, hands-on activities and structured reflection. Its main components included:

- Welcome and presentation of the training objectives.
- Introduction to the IGNITE online application and e-assistant.
- Practical use of the competence-monitoring functions.
- Presentation and testing of data-transfer procedures.
- Presentation and peer review of the developed nanomodules.
- Completion of pre- and post-tests.
- Testing of the application and review of the generated results.
- Final discussion and feedback session.

This combination enabled participants to examine the IGNITE outputs from different perspectives: as educators, content developers, application users, and project partners responsible for transferring the approach to their institutions. The practical sessions were particularly important because participants could test the application, review the nanomodules and discuss their possible integration into teaching practice.

The training involved 16 higher-education staff members from all six partner countries, exceeding the project target of 15 participants and achieving the planned six-country coverage. The activity therefore met both quantitative indicators defined for staff training within WP3.

Of the 16 staff members participating in the training, ten completed the evaluation questionnaire. The demographic profile presented below therefore refers to the evaluation respondents rather than to the full training cohort. Seven respondents were female, and three were male. The largest age group was 36-45 years, representing five respondents, followed by four participants aged 26-35 and one participant aged over 56.

The group had a high educational profile: six participants held a Master's degree, three held a PhD, and one held a Bachelor's degree. Participants represented Greece, Slovenia, France, Spain and Norway. Greece accounted for four respondents, Slovenia for three, while France, Spain and Norway were represented by one respondent each. Although participants from all six partner countries attended the training, no respondent from Belgium completed the evaluation questionnaire.

Although the sample was relatively small, it reflected most of the international composition of the consortium and included professionals with the educational and institutional experience required to assess the relevance, usability and transferability of the developed outputs.

8.2 Overall training experience and organisation

The staff training received a highly positive overall evaluation. Eight of the ten respondents gave the highest possible score to the statement that the training met their expectations. The same number considered the sessions well facilitated and easy to follow.

Active participation was another highly rated aspect. Eight respondents strongly agreed that the trainers encouraged participants to contribute, ask questions and engage with the activities. This indicates that the training was not perceived as a one-directional presentation but as an interactive capacity-building process.

The training venue received the strongest result, with all ten respondents assigning the highest score to its comfort and appropriateness. Relevant examples and practical cases were also highly appreciated, with nine respondents giving this aspect the highest score.

Seven participants strongly agreed that the knowledge and skills acquired during the training would support their future professional or teaching activities. The remaining responses were also positive, indicating strong perceived potential for transferring the acquired knowledge and skills beyond the immediate project context.

These findings suggest that the training successfully combined appropriate organisation, relevant content and active participation. Its structure provided a supportive environment in which project staff could familiarise themselves with the IGNITE tools and reflect on their potential application in different institutional settings. Together with the participation data, these findings show that the training achieved both its planned reach and a high level of participant satisfaction.

8.3 Evaluation of individual sessions and activities

The individual training components were also evaluated very positively.

The welcome session and presentation of the training objectives received the highest score from eight respondents. This indicates that the purpose, structure and expected results of the training were communicated clearly from the beginning.

The presentation of the IGNITE online application and e-assistant was rated as clear and useful by eight participants. The results indicate that participants perceived the presentation as an effective introduction to the role of the application within the wider IGNITE learning pathway.

The hands-on session covering competence monitoring and data transfer received the highest rating from eight respondents. Its practical character enabled participants to move beyond a theoretical understanding of the application and test how learner data, assessments and competence-development results could be managed.

The nanomodule presentations were among the most highly rated activities. Nine respondents gave them the highest score for relevance and informativeness. This finding is consistent with the separate nanomodule evaluation, which showed strong acceptance of the video duration, common templates and overall digital-learning format.

The pre- and post-test activities also received the highest rating from nine respondents. Their positive evaluation suggests that participants valued the inclusion of pre- and post-assessment as part of the learning and competence-monitoring process.

Eight respondents gave the highest score to the practical testing of the application and the review of the generated results. The final feedback session received the highest score from seven participants, while the remaining responses were also positive.

Overall, the results demonstrate that the strongest elements were those combining explanation with practical testing. Presentations were most effective when followed by opportunities to use the tools, review results and discuss implementation with other participants. The results therefore support the use of staff training not only as a dissemination activity, but also as an internal testing and quality-assurance mechanism for the IGNITE learning ecosystem.

8.4 Qualitative feedback

The open-ended responses reinforced the positive quantitative findings. Participants highlighted the clarity, structure, practical relevance and interactive character of the training. As only a limited number of open-ended comments were provided, these qualitative findings should be interpreted as illustrative rather than representative of the full participant group.

One respondent characterised the training as highly effective and emphasised that its structured approach made the learning process smooth and impactful. Another participant valued the opportunity to participate actively and exchange opinions with colleagues. The location, discussions and structure of the nanomodules were also identified as positive elements.

Most respondents did not report major weaknesses. However, one participant suggested adopting a more systematic working process and preparing part of the required content before the training. This feedback indicates that limited training time could be used more effectively if participants completed short preparatory activities in advance.

The qualitative evidence therefore suggests the value of a blended capacity-building model consisting of:

1. Preparatory material before the training.
2. Short presentations and demonstrations during the event.
3. Hands-on testing and adaptation.
4. Peer discussion and feedback.
5. Follow-up support after the training.

8.5 Strengths and areas for improvement

Strengths	Areas for improvement
Clear training objectives and well-structured programme	Provide preparatory materials and tasks before the training.
Effective combination of presentations and practical activities	Allocate additional time for hands-on testing and institutional adaptation.
High-quality facilitation and encouragement of active participation	Use differentiated activities for educators, administrators and content developers.

Strengths	Areas for improvement
Highly valued nanomodule presentations and pre/post-test activities	Include more opportunities for participants to create or revise their own materials.
Strong practical focus on the application and competence monitoring	Provide clearer step-by-step technical guidance for data transfer and result interpretation.
International participation involving HE staff from all six partner countries	Facilitate more structured peer learning between institutions and disciplines.
High perceived professional and teaching relevance, with 7/10 respondents giving the highest rating	Measure whether participants subsequently apply the tools in their professional practice.
Very positive organisational and venue evaluation	Maintain logistical quality when replicating the training in other institutions.
Participation target exceeded: 16 HE staff from all six partner countries, compared with the target of 15	Maintain broad institutional representation and aim for evaluation responses from all participating countries.

8.6 Recommendations

- Ask participants to bring one course, learning activity or assessment from their institution that could be adapted using the IGNITE approach.
- Maintain the combination of explanation, demonstration, practical testing and reflection, as this was one of the most successful elements of the training.
- Develop role-specific practice scenarios for educators, content developers, application administrators and project managers.
- Record the main demonstrations or prepare short video tutorials so that participants can revisit the procedures after the event.
- Allocate more time to the interpretation of competence-monitoring results and their use in teaching, advising and curriculum development.
- Conduct a follow-up evaluation after 8-12 weeks to determine whether participants used the application, nanomodules, or assessment methods and to identify barriers to institutional adoption.
- Distinguish systematically between participation indicators and evaluation-response indicators when reporting future training activities.
- Collect evaluation responses from representatives of all participating countries and, where possible, report response rates alongside satisfaction results.
- Use staff training as a formal quality-assurance checkpoint before wider student implementation, combining tool testing, pedagogical review and documented improvement actions.

9. Evaluation of the Student Workshops

9.1 Workshop design and implementation

The international student workshops were organised as pilot learning activities to test the IGNITE educational ecosystem with its intended end users. Rather than evaluating individual project outputs in isolation, the workshops enabled students to experience an integrated learning pathway combining nano-learning, competence assessment, gamified practice, self-directed learning and digital collaboration.

A common workshop framework was prepared for the participating higher education institutions. The planned learning sequence included an introduction to the IGNITE project and its digital tools, selection of a nanomodule according to individual interests, a pre-assessment in the IGNITE application, individual learning through the selected nanomodule, completion of related activities in the Virtual Learning Garden, interaction through the IgniteSphere e-room where applicable, a post-assessment, a feedback questionnaire and a final reflective discussion.

The common structure was adapted to the institutional context of each partner. The Slovenian workshop, organised by MPŠ (Jozef Stefan International Postgraduate School) on 9 February 2026, used a hybrid format and explicitly combined nanomodule selection, pre- and post-assessment, Virtual Learning Garden activities, optional IgniteSphere discussion and a final reflection session. The University of Lorraine (UL) organised its workshop on 17 April 2026 and complemented the digital learning pathway with an external professional perspective on sustainability and entrepreneurship. At UPC (Universitat Politècnica de Catalunya), 22 students followed the complete step-by-step learning process from registration and pre-testing through the Virtual Learning Garden to post-testing and review of results. The NTNU (Norwegian University of Science and Technology) workshop similarly introduced participants to the complete IGNITE learning ecosystem and supported practical use of the application, nanomodules, Virtual Learning Garden, pre-/post-assessment, statistics and certificates. The final workshop organised by Ghent University (UGent) extended the testing to students from Ghent University and Eindhoven University of Technology.

This design made the workshops more than dissemination events. They functioned as pilot implementation and validation activities, allowing students to use the learning materials and digital tools in an authentic facilitated setting and enabling the consortium to collect direct end-user feedback.

9.2 Participation and evaluation approach

Participation substantially exceeded the quantitative targets established for the international student workshops. Consolidated monitoring of the first four workshops organised by MPŠ, UL, UPC and NTNU recorded 83 students, 11 lecturers and two external stakeholders, already exceeding the WP3 targets of 40 students and eight lecturers before the final UGent workshop was implemented. The later UGent workshop involved a further 14 participants, including higher-education students and lecturers.

The evaluation questionnaire was designed to assess several complementary aspects of the learning experience:

- nanomodules and short educational videos;

- the IGNITE Competence Monitoring Application;
- the Virtual Learning Garden;
- the IgniteSphere e-room;
- workshop organisation and implementation;
- qualitative perceptions of the most valuable elements and suggestions for improvement.

Responses were collected using a five-point Likert scale ranging from 1 – strongly disagree to 5 – strongly agree, complemented by open-ended questions. The questionnaire therefore provided evidence not only of satisfaction with individual digital tools, but also of how well the different components worked together during an authentic learning activity.

A total of 33 questionnaire responses were collected. Thirty-one respondents were students and two were lecturers. To maintain consistency with the primary target group of the activity, the quantitative analysis presented in this chapter focuses on the 31 student responses. Because the questionnaire responses represent a subset of all workshop participants, the findings should be interpreted as evidence of perceived quality and usability rather than as a complete census of all participants.

9.3 Student evaluation of the learning components

Nanomodules and short educational videos

The nanomodules received the strongest overall evaluation among the digital learning components. Across the five questionnaire items related directly to the nanomodules and videos, the average rating was 4.50/5, and 93.5% of all ratings were either agree or strongly agree.

Student evaluation item	Average rating
Videos were clear and easy to follow	4.58 / 5
Nanomodules helped students understand the topic in a concise and engaging way	4.52 / 5
Ability to choose a nanomodule based on personal interests increased motivation	4.52 / 5
Video duration was appropriate for effective learning	4.39 / 5
Students would recommend the nanomodules to peers	4.48 / 5

Thirty of the 31 students agreed or strongly agreed that the videos were clear and easy to follow. The same number positively evaluated the possibility of choosing a nanomodule according to their interests. These results support the student-centred design principle of allowing learners greater autonomy over the topics they explore.

The slightly lower, although still very positive, score for video duration suggests that the short-form learning format worked well overall, but that content length may need to remain flexible for more complex scientific topics.

Virtual Learning Garden

Students also evaluated the Virtual Learning Garden positively. Across the three VLG-related questionnaire items, the overall average was approximately 4.01/5.

Virtual Learning Garden evaluation item	Average rating
VLG activities supported active and self-directed learning	4.06 / 5
VLG activities helped students apply knowledge gained from the nanomodules	4.00 / 5
VLG activities were well connected to the nanomodules and competence tests in the IGNITE application	3.97 / 5

Approximately 71% of the ratings across these three items were agree or strongly agree. The results indicate that the Virtual Learning Garden successfully moved students beyond passive viewing of learning content. Interactive exercises and quizzes enabled learners to practise and apply knowledge introduced through the nanomodules, while the self-paced format supported learner autonomy. The comparatively lower score for the connection between the VLG, nanomodules and application indicates that the pedagogical logic of the ecosystem was generally understood but that the technical and navigational links between the platforms could be made more seamless.

IGNITE Competence Monitoring Application

The student evaluation of the application was positive but more varied than the evaluation of the nanomodules. Across five application-related items, the average rating was approximately 3.87/5.

IGNITE application evaluation item	Average rating
Pre- and post-tests were useful for assessing competence development	4.19 / 5
The application supported learning during the workshop	4.13 / 5
Graphic design and user-friendliness	3.77 / 5
The e-advisor was useful for further competence development	3.65 / 5
The application was easy to use	3.61 / 5

Approximately 69% of all ratings across the five application items were agree or strongly agree. The strongest student evaluation concerned the application's core pedagogical function: pre- and post-assessment. This confirms that students recognised the value of using the application to connect a learning activity with assessment of progress. The application was also positively perceived as supporting learning during the workshop.

The lower scores for ease of use and the e-advisor indicate that the application was educationally relevant but that the user journey could still be simplified. This is consistent with observations from the workshops, where participants had to move between the application, the Virtual Learning Garden and external video resources.

The final project presentation also summarised the student validation of the application, reporting that approximately 88% found the application useful for pre- and post-testing, 82% considered that it

supported their learning, and around two thirds positively evaluated ease of use. This confirms that the strongest aspect of the application was its role in supporting assessment and reflection on learning progress.

9.4 Learning outcomes and competence development

The workshop reports provide additional evidence concerning the learning outcomes generated by the integrated workshop format. Students were not only exposed to sustainability-oriented content but were required to navigate a multi-step digital learning pathway. This supported the development of several interconnected competences:

- **digital literacy**, through use of the application, learning-management environment and online collaboration tools;
- **self-assessment and reflective learning**, through pre- and post-tests and review of individual results;
- **self-directed learning**, through independent selection of nanomodules and completion of learning activities;
- **sustainability awareness**, through exposure to scientific, environmental and societal challenges;
- **innovation and entrepreneurial awareness**, through the connection between sustainable challenges, technology and future applications;
- **interdisciplinary learning**, through access to nanomodules outside students' immediate disciplinary backgrounds;
- **learning-to-learn competences**, through progress monitoring and identification of further learning needs.

The UPC report, for example, identified digital literacy, self-assessment and sustainability awareness as key competences supported during the workshop and reported that students considered the short-video and interactive-quiz format helpful for autonomous learning. It also highlighted specific user suggestions concerning more direct integration between the application and learning materials. The NTNU report similarly identified digital literacy, self-assessment, autonomous learning, reflection on personal skills development and awareness of sustainable innovation and entrepreneurship as relevant outcomes of the workshop.

The student workshops therefore provided an important validation bridge between tool development and authentic educational use. The project outputs were tested not as stand-alone resources but as interconnected elements of a learning pathway.

9.5 Qualitative feedback

The open-ended questionnaire responses and workshop reports reinforce the quantitative findings. Students particularly valued:

- concise and accessible explanations of complex topics;
- the possibility of exploring topics outside their usual disciplinary field;

- the broad and interdisciplinary selection of sustainability-related subjects;
- the ability to choose learning content according to personal interests;
- flexible and self-paced video learning;
- interactive exercises accompanying the learning materials;
- the combination of visual explanations, videos and quizzes;
- the possibility of monitoring progress through pre- and post-assessment.

The qualitative feedback also identified several areas for further improvement. A recurring recommendation concerned stronger technical integration between the IGNITE application and the Virtual Learning Garden. Participants suggested that the same user account should provide access to both environments. The UPC workshop report explicitly noted requests for direct access to learning videos from the application and for a common account for the application and the Virtual Learning Garden.

Other suggestions included:

- improving mobile compatibility;
- simplifying navigation and the user interface;
- adding more practical examples and interactive activities;
- increasing opportunities for live discussion and peer interaction;
- improving audio quality and subtitles where needed;
- providing greater depth for selected complex nanomodule topics;
- further standardising assessment questions and quiz procedures;
- making the relationship between learning content, assessment and subsequent recommendations more transparent.

The **IgniteSphere e-room** provided an additional opportunity for discussion and interdisciplinary exchange. However, its use varied between workshops: in some agendas it was integrated as a discussion component, while in others participation was optional or more limited. Future implementations would benefit from making the e-room or an equivalent collaborative task a more structured part of the workshop pathway, rather than an optional additional activity.

Overall, the qualitative evidence confirms that students responded positively to the integrated digital learning approach while identifying usability and integration issues that are typical when several digital environments are combined within one learning journey.

9.6 Strengths and areas for improvement

Strengths	Areas for improvement
Strong student acceptance of the nanomodules, with an overall average of 4.50/5 and 93.5% positive ratings	Maintain flexible video length and provide greater depth for complex topics where required.

Strengths	Areas for improvement
Student choice of nanomodule increased motivation (4.52/5)	Preserve learner choice while providing clearer recommended learning pathways for students who need more guidance.
VLG supported active and self-directed learning (4.06/5)	Increase interactivity, explanatory feedback and practical application within exercises.
Positive connection between nano-learning and interactive practice	Make transitions between nanomodules, VLG activities and assessment more seamless and visible.
Pre-/post-assessment was the highest-rated application feature (4.19/5)	Further standardise assessment items and improve the presentation and interpretation of results.
Application supported learning during the workshops (4.13/5)	Simplify onboarding, navigation and mobile use.
Integrated Learn–Practice–Assess pathway tested in authentic student activities	Introduce a common login or single-sign-on across the application and Virtual Learning Garden.
Workshops supported digital literacy, self-assessment, autonomous learning and sustainability awareness	Link workshop activities more explicitly to defined competences and intended learning outcomes.
Interdisciplinary range of nanomodules enabled students to explore unfamiliar topics	Provide optional preparatory guidance for students entering topics outside their discipline.
Common workshop framework enabled implementation across different HE institutions and formats	Maintain a common core structure while documenting local adaptations consistently.
Participation substantially exceeded the planned student and lecturer targets	Improve the consistency of evaluation-response collection across all workshops and participant groups.
Qualitative feedback provided concrete suggestions for further tool development	Integrate structured peer discussion and IgniteSphere participation more consistently into the workshop design.

9.7 Recommendations

Based on the workshop implementation evidence and student evaluation results, the following recommendations are proposed:

- Maintain the integrated learning sequence of pre-assessment → nanomodule → interactive practice → post-assessment → reflection, as this creates a clear connection between learning content and competence development.

- Preserve learner choice of nanomodules, since the ability to select content according to personal interests was one of the most positively evaluated motivational elements.
- Develop a single-sign-on or unified user account for the IGNITE application and the Virtual Learning Garden and enable direct navigation between assessment, videos, exercises and results.
- Optimise all components for mobile use and different screen sizes, and conduct systematic accessibility testing.
- Provide a short onboarding pathway showing students where to start, which tool to use at each stage and how the different elements of the learning ecosystem are connected.
- Continue to use short and visually engaging learning units, while allowing longer or more detailed optional content for topics requiring greater scientific depth.
- Expand the use of practical examples, authentic cases, interactive activities and live discussions to strengthen the connection between digital content and real-world application.
- Standardise pre- and post-assessment items across nanomodules and provide clearer explanatory feedback so that students can understand not only their scores but also what they should learn next.
- Further develop the e-advisor by making the basis for its recommendations transparent and linking suggestions more directly to assessment results and learning pathways.
- Integrate the IgniteSphere e-room or another collaborative activity as a defined workshop task, with a clear discussion question or reflection prompt, rather than leaving participation optional.
- Collect the same minimum evaluation dataset across all future workshops and clearly distinguish between total participants, questionnaire respondents, students and lecturers.
- Complement immediate satisfaction questionnaires with short follow-up evaluation, for example after several weeks, to determine whether students subsequently used the nanomodules, application or VLG independently.
- Where possible, combine questionnaire data with application and VLG analytics to examine actual engagement, completion and learning progress, rather than relying exclusively on perceived usefulness.
- Retain the common workshop framework as a transferable model for implementation in STEAM higher education, while allowing institutions to adapt examples, external speakers and discussion topics to their disciplinary and regional context.

10. Evaluation of the Multiplier Events and Final Conference

10.1 Purpose and dissemination approach

The national multiplier events and the IGNITE Final Conference represented the main stakeholder-oriented dissemination activities implemented during the final phase of the project. Their purpose was to present the developed project results beyond the immediate consortium, gather feedback from external audiences, assess the perceived relevance and transferability of the outputs, and identify opportunities for further use after the end of the funded project period.

Six national multiplier events were organised across the participating countries, targeting students, educators, researchers, industry representatives, public organisations and other stakeholders. The national events were deliberately adapted to local audiences and contexts, ranging from student- and sustainability-oriented awareness activities to professional stakeholder events explicitly focused on exploitation and integration of IGNITE results into continuing education and future collaboration. The events were intended not only to communicate the project outputs but also to stimulate discussion about how innovative learning approaches can support sustainability, entrepreneurship and competence development in different institutional and national contexts. The project dissemination strategy explicitly used these national events to bring project results to audiences beyond the partnership and beyond the classroom.

The stakeholder evaluation questionnaire was designed specifically to assess the quality of the events, the relevance of the presented project results and the potential impact of IGNITE on higher education, sustainable innovation and stakeholder collaboration. The feedback was also intended to inform the final project evaluation and future dissemination and stakeholder-engagement activities.

In addition to the national events, the international IGNITE Final Conference was organised by MPŠ in Ljubljana on 27 August 2026. The event was implemented in a hybrid format, enabling both physical and online participation, and brought together project partners and wider stakeholders.

10.2 National multiplier events

The six national multiplier events were designed to adapt the presentation and exploitation of IGNITE results to national and stakeholder contexts. Although they shared the common objective of disseminating the project outputs and promoting their further use, the events were implemented in different formats and were adapted to the needs of local target groups.

The available documentation confirms substantial participation and a strong practical orientation of the national events. In France, the University of Lorraine organised the multiplier event in Nancy on 25 June 2026 with 20 documented participants. The programme combined a keynote on renewable energy technologies with a presentation of the IGNITE results, hands-on exploration of the learning tools and a discussion session. The attendance list shows a particularly international student audience, complemented by an industry expert/professor and university international-relations staff.

Innovation Hive organised the Greek multiplier event in Larissa on 19 June 2026, with 20 participants documented in the event agenda. The event combined awareness raising on environmental challenges

and sustainable living with presentation and practical exploration of the IGNITE learning ecosystem. Participants were introduced to the project's main outputs, including the nano-learning modules, Virtual Learning Garden, Competence Monitoring Application, IgniteSphere e-room and Innovation Marathon, and were given the opportunity to explore selected learning resources through hands-on activities. Photographic documentation shows direct interaction with visitors through practical sustainability-themed activities and discussions, indicating that the event went beyond one-way dissemination and actively engaged participants with the topics of sustainable living and the IGNITE approach.

The Slovenian multiplier event, organised by MIITR in Maribor on 12 August 2026, was delivered in hybrid format. The available evidence documents six onsite signatures and seven participants visible in the Microsoft Teams participant list, providing 13 attendance records across the two participation modes.

The Norwegian event provides a particularly strong example of exploitation rather than dissemination alone. NTNU organised a hybrid event in Trondheim on 31 August 2026 with 11 participants, three attending onsite and eight online. Participants represented higher education, healthcare, consulting, sustainability organisations and other professional stakeholders. The event demonstrated how elements of the IGNITE approach were being transferred to the Helseveven network and the new BM6105 continuing-education course, including nanolearning, competence-based learning outcomes, empathic mapping and before-and-after competence monitoring.

UPC implemented the Spanish multiplier event as a large-scale dissemination and stakeholder-engagement activity centred on the presentation of the IGNITE project and its main results. The participant register contains 94 named entries representing a broad range of research groups and academic units from Barcelona, Terrassa and Vilanova i la Geltrú, demonstrating particularly strong reach within the university and research community. The IGNITE poster presented the project foundations and empathetic approach, key findings on student learning preferences, the Virtual Learning Garden and digital ecosystem, innovative educational outputs, and the Innovation Marathon. QR codes provided direct access to the project resources and website. Photographic documentation shows participants engaging directly with the IGNITE poster during the event, enabling informal discussion, explanation of the project approach and exchange with members of the wider academic and research community. The Spanish multiplier therefore achieved substantial dissemination reach while providing a visible and accessible format for presenting the integrated IGNITE learning ecosystem.

Country	Host	Date	Participants
France	University of Lorraine	25 June 2026	20
Greece	Innovation Hive	19 June 2026	20
Norway	NTNU	31 August 2026	11
Slovenia	MIITR	12 August 2026	13
Belgium	UGent	28 August 2026	14
Spain	UPC	15 July 2026	94

Across the national events, partners therefore moved beyond one-way dissemination. Participants were given opportunities to explore project resources, discuss their applicability and consider further use in education and professional practice. Photographic documentation also confirms face-to-face engagement and practical interaction with participants at several of the national events.

10.3 Final Conference

The Final Conference was conceived as the main international closing event of the project and as an opportunity to present the complete IGNITE learning ecosystem rather than individual outputs in isolation.

The programme covered the project journey from student needs to innovative learning, the development of nanolearning modules, the Virtual Learning Garden, the Innovation Marathon, evaluation of student sustainability projects, virtual and practical student workshops, digital tools for competence development and career guidance, recommendations for integration into STEAM higher education and dissemination and sustainability. The event concluded with a panel discussion and networking component.

The programme demonstrated the contribution of the full partnership: MPŠ presented the overall project framework and competence-monitoring application; UL addressed nanolearning; MIITR presented the Virtual Learning Garden and dissemination; UPC presented the Innovation Marathon; UGent reflected on the international jury evaluation; NTNU presented experiences from virtual and practical workshops; and Innovation Hive presented recommendations for future integration.

The conference registration form recorded 32 registrations, of which 21 participants (65.6%) planned to participate online via Zoom and 11 (34.4%) in person. The registered audience was diverse: 14 registrants were lecturers/professors or other higher-education staff, seven were students, while the remaining registrants represented NGOs/civil-society organisations, companies, adult education, a public authority, research and the wider community. The registration data also demonstrate alignment between the conference programme and stakeholder interests. The most frequently selected topics were:

Topic selected during registration	Registrants	% of registrations
Digital tools for competence development	20	62.5%
International collaboration	18	56.3%
Sustainability competences	15	46.9%
Innovative teaching methods	14	43.8%
Virtual Learning Garden	14	43.8%
Nano-learning modules	12	37.5%
STEAM education	12	37.5%
Entrepreneurship	10	31.3%
Innovation Marathon	8	25.0%

Actual participation was subsequently verified using the available onsite attendance list and Zoom participation evidence. The signed onsite attendance list contains 14 participants, while the Zoom screenshot shows 15 connections during the event. The difference between the 32 registrations and the documented attendance is expected, as registration indicates intention to participate whereas the attendance records capture verified participation. The hybrid format nevertheless enabled substantially broader participation than an onsite-only event and supported international access to the project results.

This profile confirms that the Final Conference attracted participants with interests extending beyond one specific project tool and that digital competence development, international collaboration and sustainability-oriented education were particularly relevant themes.

10.4 Evaluation methodology and respondent profile

Stakeholder feedback from the multiplier events and Final Conference was collected using a common questionnaire. Respondents evaluated the events using five-point scales and provided qualitative feedback concerning the future use and implementation of project results. The evaluation covered three main dimensions:

1. **Event quality and participant experience**, including overall satisfaction, organisation, fulfilment of expectations, quality of presentations and networking opportunities.
2. **Perceived relevance and transferability of project results**, including innovation and usefulness of the outputs, relevance of the digital learning methods, usefulness of the e-guide and willingness to recommend the resources.
3. **Potential impact**, including increased awareness of sustainable learning solutions, motivation to apply sustainable practices and support for collaboration between higher education institutions and external stakeholders.

A total of 30 valid responses were collected:

- 20 responses from National Multiplier Event participants;
- 10 responses from Final Conference participants.

Among all respondents, 22 (73.3%) represented higher education institutions, four were students and four represented research institutes. Respondents came from eight countries, providing an international perspective on the perceived relevance of the project results.

The evaluation sample should nevertheless be interpreted as a feedback sample rather than as a complete representation of all event participants. In particular, responses were not distributed equally across all six national multiplier events. The findings therefore provide strong indicative evidence of stakeholder perception but should not be used to compare national events directly.

10.5 Quantitative evaluation results

The combined results from the 30 stakeholder responses were highly positive. The average overall satisfaction was 4.70/5, and 29 of the 30 respondents (96.7%) rated their overall satisfaction with the event as 4 or 5.

Evaluation item	All events (n=30)	National multiplier events (n=20)	Final Conference (n=10)
Overall satisfaction	4.70	4.65	4.80
Event was well organised	4.47	4.55	4.30
Event met expectations	4.27	4.30	4.20
Presentations were interesting and easy to follow	4.40	4.45	4.30
Discussions and networking were valuable	4.33	4.35	4.30
Project results were innovative and useful	4.40	4.45	4.30
Digital tools and learning methods were relevant for HE	4.57	4.60	4.50
E-guide provided useful implementation recommendations	4.30	4.40	4.10
Would recommend IGNITE resources	4.53	4.55	4.50
Increased awareness of sustainable learning solutions	4.40	4.55	4.10
Motivated application of sustainable practices	4.43	4.50	4.30
Encouraged HEI–stakeholder collaboration	4.30	4.35	4.20

The results show that the relevance of the digital tools and learning methods for higher education was one of the strongest findings (4.57/5). This is particularly important because the objective of the dissemination activities was not simply to increase project visibility but also to demonstrate that the developed methods could be useful outside the original pilot context.

Similarly, willingness to recommend the IGNITE resources received a high overall score of 4.53/5, while perceived innovation and usefulness of the project results was rated 4.40/5.

National multiplier events

Feedback from the national multiplier events was consistently positive. Overall satisfaction reached 4.65/5, with 95% of respondents assigning a positive rating of 4 or 5. The strongest results concerned:

- relevance of the developed digital tools and learning methods for higher education: 4.60/5;
- organisation of the events: 4.55/5;
- willingness to recommend the project resources: 4.55/5;
- increased awareness of sustainable learning solutions and innovation: 4.55/5;
- motivation to apply sustainable practices: 4.50/5.

Even the lowest-scoring dimensions remained positive: whether the event met expectations received 4.30/5, while networking and HEI–stakeholder collaboration each remained above 4.3/5.

The findings indicate that the multiplier events were effective not only in disseminating project results but also in communicating their practical relevance, sustainability dimension and potential for further educational use.

Final Conference

The Final Conference received the highest overall satisfaction score, 4.80/5, with all ten respondents rating their overall satisfaction as 4 or 5.

Particularly positive results were obtained for:

- relevance of the digital tools and learning methods for higher education: 4.50/5;
- willingness to recommend IGNITE resources: 4.50/5;
- overall organisation, presentation quality, networking opportunities and perceived usefulness of results, all approximately 4.3/5.

The e-guide and the item concerning increased awareness of sustainable learning solutions received the lowest averages within the conference evaluation (4.10/5), although the scores remained clearly positive.

Given the small number of Final Conference evaluation responses (n=10), these results should be interpreted descriptively. Nevertheless, they provide positive evidence that the closing event effectively communicated the project results and generated interest in their further use.

10.6 Future use and exploitation potential

The stakeholder questionnaire provides particularly strong evidence concerning the potential for post-project exploitation. Across all 30 respondents:

- 21 respondents (70%) indicated that they would be interested in using or promoting IGNITE results in the future;
- six respondents (20%) answered “Maybe”;
- only three respondents (10%) answered “No”.

Respondents could select several project results that they would be most interested in using. The most frequently selected were:

Project result	Number of respondents	Share of all respondents
Virtual Learning Garden	18	60.0%
Nanolearning Modules	16	53.3%
Competence Monitoring Application	11	36.7%
Innovation Marathon	9	30.0%
E-guide	6	20.0%

Project result	Number of respondents	Share of all respondents
IgniteSphere Community	5	16.7%

The Final Conference responses showed especially strong interest in the Nanolearning Modules (8/10 respondents) and Virtual Learning Garden (7/10 respondents).

Qualitative responses identified several concrete pathways for future use. Respondents proposed:

- integrating nanomodules and the Virtual Learning Garden into existing courses;
- using short videos as pre-class learning material;
- offering IGNITE materials to bachelor-level students at the beginning of courses;
- using the results to support staff development and institutional educational innovation;
- using the Innovation Marathon as a project-oriented teaching method;
- sharing resources through internal research-group presentations and training;
- using IGNITE as a basis for a sustainability-focused elective course;
- supporting multidisciplinary sustainability projects using expertise and facilities from different fields;
- sharing and promoting the outputs through institutional and social-media channels.

These responses provide evidence of transferability from project activities to teaching, curriculum development, professional learning and institutional collaboration.

The dissemination approach presented at the Final Conference explicitly positioned the results as reusable resources for different audiences: students, educators, HE institutions, researchers, companies, NGOs and other stakeholders. The project also emphasised continued access to the results and community beyond the formal project lifetime.

10.7 Strengths and areas for improvement

Strengths	Areas for improvement
Very high overall stakeholder satisfaction (4.70/5 across 30 responses)	Increase and systematise feedback collection at every national multiplier event to achieve more balanced coverage across countries.
Strong perceived relevance of IGNITE digital tools and learning methods for higher education (4.57/5)	Provide clearer implementation pathways, technical guidance and ready-to-use examples for organisations wishing to adopt the tools.
High willingness to recommend IGNITE resources (4.53/5)	Develop concise dissemination packages tailored to different target groups such as educators, institutional managers, students and external stakeholders.

Strengths	Areas for improvement
Strong evidence of future-use potential: 70% Yes and a further 20% Maybe	Follow up with interested organisations to determine whether intended use leads to actual adoption.
Virtual Learning Garden and Nanolearning Modules generated particularly strong stakeholder interest	Maintain and update learning content and ensure continued technical accessibility after the project.
Some multiplier events demonstrated concrete exploitation beyond dissemination, particularly the transfer of IGNITE approaches into continuing education and professional networks.	Systematically document follow-up actions and actual post-event adoption of project results.
Hybrid Final Conference enabled participation beyond Ljubljana	Retain hybrid access but improve systematic tracking of unique online and onsite attendance.
Conference programme presented the full Learn–Practice–Apply ecosystem and contributions from the wider consortium	Allow additional time for practical demonstrations and stakeholder discussion of implementation cases.
Stakeholder comments identified concrete curricular, staff-development and sustainability-course applications	Convert examples of planned use into short documented exploitation cases or institutional good practices.
Events supported dialogue between higher education, research and external stakeholders	Strengthen structured networking and follow-up mechanisms to turn contacts into continued collaboration.
Results were disseminated through national, international and scientific channels	Continue coordinated post-project communication so that results remain visible after funding ends.

10.8 Recommendations

Based on the multiplier-event and Final Conference evaluation, the following recommendations are proposed:

- Continue to make the Nanolearning Modules, Virtual Learning Garden and other core learning resources openly accessible after the project period and ensure that links and technical environments remain functional.
- Develop concise implementation packages for educators and institutions, including examples of how nanomodules, the VLG, pre-/post-assessment and the Innovation Marathon can be embedded into existing courses.
- Follow up with stakeholders who expressed interest in future use and document actual post-project adoption, rather than relying only on stated intention.

- Develop several short exploitation case studies, for example integration into an existing university course, use of nanomodules as pre-class material, use within continuing education or implementation of an Innovation Marathon-type activity.
- Maintain a hybrid format for major dissemination events to support international accessibility, while introducing a consistent system for recording unique online and onsite attendance.
- Use a common minimum feedback questionnaire across all multiplier events and aim to collect sufficient responses from each participating country and stakeholder group to support more robust comparative analysis.
- Strengthen structured networking by introducing facilitated stakeholder discussions, thematic breakout groups or short implementation-planning sessions during dissemination events.
- Provide clearer demonstrations of the e-guide and IgniteSphere Community, as these outputs generated less explicit stakeholder interest than the learning materials and digital tools.
- Continue communication through the project website, social media, partner networks and scientific channels and periodically highlight examples of how project outputs are being reused after project completion.
- Use the high level of stakeholder interest in the Virtual Learning Garden and Nanolearning Modules as a basis for future project proposals, institutional cooperation and further development of the IGNITE learning ecosystem.
- Conduct a post-project follow-up survey after six to twelve months to determine which resources have actually been reused, adapted or integrated and to identify barriers to longer-term institutional adoption.

11. Integrated Findings

11.1 Coherence of the IGNITE learning cycle

The main evaluative conclusion is that the components reinforce one another when implemented as a coherent cycle. The empathy questionnaire informs the design of visual, structured, and relevant nanomodules. The Virtual Learning Garden provides practice and visible progression. The competence application supports self-assessment and next-step guidance. The e-advisor extends this pathway by providing personalised recommendations for further competence development and career guidance. The international student workshops demonstrated how these elements can be combined into an integrated learning sequence in an authentic educational setting. Staff training enables educators to implement the tools. The Innovation Marathon converts conceptual learning into authentic application and communication. The multiplier events and Final Conference extend the cycle beyond the learner level by supporting external validation, dissemination, transfer and potential post-project exploitation of the developed approaches.

The evidence therefore supports an integrated pathway that can be summarised as Understand learner needs → Learn → Practice → Assess and reflect → Apply → Transfer. The different components serve complementary functions rather than acting as isolated project outputs.

If the elements are deployed separately, much of this added value is lost. Videos risk becoming optional content, the application risks becoming a stand-alone questionnaire, badges risk becoming superficial rewards, and the Marathon risks becoming an isolated competition. Integration should therefore be an explicit curriculum and platform requirement. Student feedback reinforces this conclusion: one of the clearest improvement priorities was more seamless integration between the IGNITE application and the Virtual Learning Garden, including common login, simpler navigation and clearer progression between learning, practice and assessment.

11.2 Evaluation against criteria

Criterion	Overall assessment	Rationale
Quality and effectiveness	Strong	Multiple evidence sources confirm positive implementation and perceived educational value: nanomodules were highly rated by students, the VLG showed active participation and generally high quiz achievement, staff training and the Innovation Marathon received positive evaluations, and external stakeholder satisfaction reached 4.70/5.
Relevance	Strong	Learner preferences, sustainability challenges and competence needs were directly addressed, while student and stakeholder feedback confirmed the relevance of the developed learning methods and digital tools.

Usability	Generally strong, with integration improvements needed	Staff rated the application highly for ease of use and navigation, while students positively evaluated both the application and VLG. However, student feedback identified onboarding, mobile usability, common login and smoother navigation between the application and VLG as priorities for improvement.
Engagement	Demonstrated, with further longitudinal monitoring desirable	Engagement is supported by positive student evaluations, 32 VLG participants, 63 quiz attempts, repeated application use across nanomodules and participation in challenge-based activities. Longer-term return and sustained use beyond facilitated project activities were not systematically measured.
Competence development	Supported by multiple indicators, but not fully quantified at individual level	Students positively evaluated pre-/post-assessment and learning support; VLG quiz achievement averaged 80.3%; the Innovation Marathon demonstrated practical application of sustainability, innovation and transversal competences; and application graphs show positive pre/post changes for a number of users. However, an overall paired learning-gain estimate could not be calculated reliably for all users.
Applicability	Strong	The methods were implemented through staff training, student workshops and challenge-based learning activities, and stakeholders identified concrete future uses in courses, pre-class learning, staff development and sustainability-focused programmes.
Transferability	Strong with contextual adaptation	The approach was implemented across several institutions and countries using common frameworks with local adaptation. External stakeholders also identified potential uses in different educational and professional settings.
Sustainability	Promising but dependent on continued institutional ownership	Stakeholder feedback showed strong future-use potential, with 70% indicating interest in using or promoting IGNITE results and a further 20% responding “Maybe”. Long-term impact nevertheless depends on technical maintenance, content updating, staff capacity, curricular integration and continued ownership of the digital environments.

11.3 Cross-cutting lessons

- Relevance and practical application are more powerful engagement levers than novelty alone.
- Short content still requires strong sequencing and curricular context.

- Usability is necessary but cannot substitute for valid assessment or learning evidence.
- Personalisation should offer meaningful routes and recommendations without labelling learners permanently.
- Staff capacity building is an outcome as well as an implementation condition.
- Common templates improve coherence, but minimum technical and pedagogical standards are still required.
- Evidence systems must be designed at the same time as learning systems.
- Integration matters as much as the quality of individual components. Students responded positively to the separate tools but consistently identified smoother navigation, common login and clearer connections between learning, practice and assessment as priorities.
- Learner choice can support motivation when it is combined with clear learning outcomes and structured guidance. This was particularly evident in the positive student response to selecting nanomodules according to individual interests.
- Digital analytics and participant feedback provide complementary evidence: satisfaction data explain how learners perceive an activity, while platform analytics show whether and how the tools are actually used. Both are needed for robust evaluation.
- Pre-/post-assessment is valuable for learner reflection, but meaningful impact evaluation requires consistently paired data, clear handling of missing values and standardised assessment items.
- Challenge-based learning adds value when mentoring, common project structures, authentic problems and transparent evaluation criteria are combined. The Innovation Marathon showed that practical application can connect sustainability knowledge with innovation, teamwork and communication.
- Transferability is strengthened when a common pedagogical core is retained but implementation is adapted to local disciplinary, institutional and national contexts.
- Dissemination is most valuable when it moves beyond awareness raising towards exploitation. Stakeholder feedback and multiplier events showed particular value when participants could identify concrete ways to reuse resources in courses, staff development or professional learning.
- Sustainability should be treated as both a learning objective and an implementation requirement: project resources need continued ownership, maintenance, updating and institutional embedding if their educational value is to continue after the funded period.

12. Recommendations for Integrating Innovative Learning Methods into STEAM Programmes

12.1 Curriculum design

Embed the IGNITE cycle within existing modules rather than adding it as an optional parallel platform. The learning pathway should follow a coherent progression from understanding learner needs, through learning and practice, to assessment, reflection, application and transfer. A typical implementation can allocate pre-class nanomodules and diagnostics, in-class application and discussion, Virtual Learning Garden practice, competence reflection, and a team challenge or mini-Marathon. Where appropriate, the competence-monitoring application and e-advisor can be used to support self-assessment and identification of subsequent learning needs. Each component should map to programme outcomes and scheduled learning hours.

Institutions should retain a common pedagogical core while adapting examples, challenges, delivery formats and disciplinary contexts to local needs. The different IGNITE components do not need to be used in every course, but those selected should form a clearly connected learning sequence rather than a set of isolated digital resources.

12.2 Teaching methods

Use blended learning, problem-based learning, challenge-based learning, guided inquiry and interdisciplinary project work. Nanomodules should prepare learners for interaction rather than replace teaching. Short, visually structured content should be followed by opportunities to practise, discuss, apply and reflect, as the project evidence consistently showed the value of combining concise learning resources with active learning. Educator time should focus on misconceptions, application, feedback, synthesis and coaching.

Provide learners with meaningful choice of topic, example or route where this does not compromise common learning outcomes. For challenge-based activities, combine learner autonomy with clear project milestones, mentoring arrangements and transparent expectations.

Staff development should accompany implementation. Educators should receive opportunities to test the tools themselves, interpret learning analytics and competence-assessment results, and discuss how the methods can be integrated into their own teaching.

12.3 Digital tools

Adopt a modular architecture that allows institutions to use the resources through existing learning-management systems where possible. Apply single sign-in, accessible design, mobile compatibility, simple data export and clear support routes. Navigation between learning content, practice activities, assessment results and recommendations should be as seamless as possible, since students identified fragmentation between the application and the Virtual Learning Garden as a recurring improvement priority.

AI-supported recommendations should be transparent, advisory and subject to human oversight. Learners should be informed about how recommendations are generated and how they relate to their competence profile, previous assessment results and suggested next steps.

Digital systems should distinguish clearly between registered users, active users, completed activities and assessment attempts. Where pre- and post-assessment is used, the platform should enable anonymised export of paired data so that learning progress can be evaluated reliably. Missing, incomplete and zero values should be coded unambiguously.

Data collection, retention, access and deletion procedures should be communicated in clear language, and learner-level summaries should only be exported or shared with explicit consent.

12.4 Student engagement

Provide choice in examples, pace and challenge topic while maintaining shared outcomes. Use co-creation selectively: students can propose cases, create short explanations, comment on prototypes or contribute to future nanomodules. Choice should be accompanied by sufficient guidance so that learner autonomy does not result in fragmented or incomplete learning pathways.

Engagement should be monitored through meaningful actions and reflection, not only views or likes. Relevant indicators include completion of learning steps, quiz attempts, repeated engagement, participation in discussions, project activity and reflective contributions.

Gamification should reinforce meaningful progress rather than function as an isolated reward system. Badges, points and certificates should therefore remain visibly connected to learning activities and achievement criteria.

Structured peer exchange should also be incorporated more deliberately through discussion prompts, peer feedback, collaborative tasks or interdisciplinary forums, as both workshop and Innovation Marathon feedback indicated the value of learning from other participants.

12.5 Assessment

Use constructive alignment. Pre/post tests should measure the stated learning outcomes at an appropriate cognitive level. Assessment items should be aligned with one clearly defined outcome, reviewed for ambiguity and duplication, and standardised sufficiently to allow meaningful comparison between pre- and post-assessment.

Combine them with project rubrics, demonstrations, portfolios, peer feedback and reflective accounts. Self-assessment should support reflection and learner awareness but should not be treated as the sole evidence of competence development.

Where projects are assessed by several evaluators, scoring rubrics should include anchored performance descriptors, evaluators should undertake a short calibration exercise, and procedures for missing scores should be defined in advance.

Badges should be issued only when evidence meets published criteria and should link to a description of the achieved competence. Learners should, where possible, receive a concise summary of their progress, achieved competences and recommended next steps.

12.6 Collaboration

Create stable collaboration structures between HEIs, industry, research organisations and community stakeholders. External partners should contribute authentic challenges, feedback, specialist knowledge or continuation pathways. Their involvement is most valuable when it begins during challenge definition or project development rather than only at the final dissemination stage.

For cross-institutional student work, establish common communication channels, shared working spaces, clear roles, minimum mentoring expectations and agreed milestones. Structured opportunities for peer learning and exchange should be planned rather than left to emerge informally.

Expectations, intellectual-property arrangements and learner safeguarding should be agreed before activity begins. Where collaboration continues beyond an individual course or project, follow-up mechanisms should document whether student projects, institutional partnerships or stakeholder relationships lead to further implementation.

12.7 Inclusion and accessibility

Apply universal design for learning: captions and transcripts; keyboard operation; sufficient contrast; readable text; alternative formats; clear language; adjustable pacing; and flexible participation routes. Digital resources should also be tested across mobile devices, screen sizes and assistive technologies rather than assuming accessibility from technical availability alone.

Provide clear onboarding for first-time and lower-confidence users and minimise the number of separate accounts or authentication steps required to participate. Hybrid and asynchronous participation routes can support wider access when they are pedagogically equivalent and technically reliable.

Monitor whether optionality genuinely reduces barriers or simply transfers support responsibilities to learners. Where possible, accessibility feedback should be collected directly from users with different levels of digital confidence and support needs.

12.8 Sustainability and institutional adoption

Assign institutional owners for content, platform administration, evaluation and stakeholder relationships. Recognise staff development and mentoring workload.

Prioritise maintenance of those outputs that showed the strongest future-use potential, while keeping clear links to the wider IGNITE learning pathway. Stakeholder interest should be followed by active support for adoption, for example through implementation examples, educator guidance, reusable course scenarios and short exploitation case studies.

Adoption should be measured through course integration, repeated use and demonstrated learner outcomes—not only continued online availability. Additional indicators should include the number of courses integrating the resources, educators reusing them, institutions adapting the methods, students returning to the tools independently, and external organisations continuing collaboration.

Long-term sustainability should therefore be understood as a combination of technical maintenance, pedagogical ownership, staff capacity, evidence of continued learner use and institutional embedding.

13. Implementation, Sustainability and Exploitation Roadmap

The roadmap translates the evaluation findings into a staged approach for post-project implementation, institutional adoption and exploitation. Particular attention should be given to maintaining the resources that generated the strongest learner and stakeholder interest, improving integration between the digital environments, strengthening learning analytics and assessment evidence, and converting expressed stakeholder interest into documented post-project use.

Horizon	Priority actions	Primary owner	Success evidence
0–6 months	Finalise quality standards; accessibility review; define indicator dictionary; revise onboarding; align assessments to outcomes. Confirm institutional ownership and hosting responsibilities for the nanomodules, VLG, application, e-advisor and IgniteSphere; ensure all public links remain operational; define procedures for paired pre-/post-assessment export and missing data; and prepare a practical plan for closer VLG–application integration and common login.	Project/institutional implementation team and designated technical/content owners	Approved standards, tested workflow, analytics specification and revised materials. Named owners, functioning resource links, maintenance responsibilities, documented assessment-data procedures and an agreed digital-integration plan.
6–12 months	Integrate into selected modules; train educators; run baseline and post-assessment; collect VLG and app analytics. Follow up with stakeholders who expressed interest in using or promoting IGNITE results; pilot the integrated Learn–Practice–Assess–Apply pathway in selected courses; and document initial institutional exploitation cases.	Programme leaders and educators with institutional/project-result owners	Course maps, staff participation, completion data and learner feedback. Paired pre-/post-data where feasible, active-user and completion analytics, documented course integrations, stakeholder follow-up and initial reuse/adoption cases.
12–24 months	Scale to additional disciplines; repeat Innovation Marathon; compare cohorts; formalise partner network. Expand adoption of nanomodules and the VLG, which generated particularly strong stakeholder interest; establish recurring staff-development opportunities; and create structured continuation pathways for high-potential student projects and external collaborations.	Faculty and external-engagement leads with programme coordinators and stakeholder partners	Multi-course adoption, calibrated project scores and stakeholder participation. Evidence of repeated use across courses, documented project continuation, cross-institutional implementation and comparative learner-outcome data across cohorts.

24+ months	Institutionalise maintenance, credentials and evidence review; publish evaluation findings. Embed successful resources into institutional teaching and quality-assurance processes; secure recurring technical and pedagogical maintenance; conduct periodic accessibility and content reviews; and monitor sustained learner, educator and stakeholder use.	Institutional governance with named academic, technical and quality-assurance owners	Recurring budget, named owners, updated resources and longitudinal evidence. Sustained course integration, updated resources, documented maintenance cycles, continued stakeholder collaboration, learner-outcome evidence and published exploitation/evaluation cases.

Prioritised recommendation matrix

Priority	Recommendation	Impact	Effort
1	Create one integrated learning pathway linking all IGNITE components and simplify transitions between the application, VLG, learning content and assessment, ideally through common login / single sign-on.	Very high	Medium–high
2	Define and collect a common minimum evaluation dataset covering registrations, unique active users, starts, completions, repeated engagement, paired pre-/post-assessments and follow-up use.	Very high	Low–medium
3	Assign named institutional owners and secure maintenance arrangements for the core IGNITE resources, particularly the nanomodules, VLG and competence-monitoring environment.	Very high	Medium
4	Strengthen assessment alignment and performance evidence through standardised items, paired-data export, clear missing-data rules and outcome-aligned project rubrics.	Very high	Medium
5	Apply accessibility and captioning standards across all content and systematically test mobile usability, onboarding and authentication with different user groups.	High	Medium
6	Standardise nanomodule technical and pedagogical review and establish a regular content-update cycle.	High	Low–medium

7	Institutionalise mentor workload and challenge-based learning and provide recurring staff-development opportunities for educators implementing the IGNITE approach.	High	Medium–high
8	Follow up with stakeholders interested in future use and document actual exploitation through course integration, staff development, institutional adaptation and external collaboration.	High	Low–medium
9	Create continuation routes for promising student projects, including further mentoring, competitions, prototyping, research collaboration or links with industry and other external stakeholders.	Medium–high	Medium

14. Monitoring and Evaluation Framework

Future implementation should use a small, stable indicator set that connects participation, experience, learning and transfer. Data should be disaggregated only where sample size and privacy permit, and all indicators should have a named owner, definition, collection point and reporting schedule. Each indicator should also have a clearly defined numerator and denominator, unit of analysis, data source and rule for handling missing, duplicate or incomplete records. Particular care should be taken to distinguish registrations, unique active users, completed activities, assessment attempts and repeated participation across modules or events.

Monitoring should combine three complementary types of evidence: participant perceptions, actual platform/activity data and evidence of learning or subsequent use. Satisfaction alone should not be interpreted as evidence of learning, while platform access alone should not be interpreted as successful completion or competence development.

Level	Core indicators	Collection point
Reach	Eligible learners, registrations, starts, active learners , unique participants, completions, participation mode (onsite/online), questionnaire response rate	Course start and platform logs ; event registration and attendance records; activity completion
Experience	Usability, accessibility barriers, relevance, support quality , overall satisfaction, perceived usefulness and open-ended feedback	After first use and activity completion
Engagement	Completion, return, practice attempts, mentor contacts, project participation , quiz attempts, successful quiz attempts, module-level participation, discussion/community activity and repeated use	During learning pathway and at activity completion
Learning	Outcome-aligned pre/post score, performance rubric, reflection quality , paired pre/post completion rate, quiz achievement, project-assessment results and demonstrated application of knowledge	Before/after module and final task
Implementation quality	Delivery against the planned learning pathway, staff preparedness, mentoring frequency, technical issues, local adaptations and implementation fidelity	During implementation and immediately after each activity
Transfer	Use in later course/project, educator adoption, stakeholder continuation , reuse of resources, institutional adaptation and continuation of student projects	8–12 week follow-up and, where feasible, 6–12 month follow-up
Equity	Completion and outcomes by relevant groups where ethical and statistically appropriate , together with accessibility barriers and support needs	Term review

Sustainability	Modules updated, courses integrating resources, trained staff, maintenance response , functioning public links, named institutional owners, repeated course use, external adoption and continued stakeholder collaboration	Annual review
Data quality	Completeness, duplicate records, proportion of paired assessments, missing-value patterns, consistency of indicator definitions and data-extraction dates	Continuous quality check and before each reporting cycle

14.1 Minimum reporting standards

- Report the denominator and response count for every percentage. Where questionnaires are used, also report the response rate whenever the total number of eligible or participating respondents is known.
- Separate staff, student, mentor and stakeholder results. Do not combine respondent groups in averages unless there is a clear analytical reason to do so.
- Retain raw anonymised data and a data dictionary under agreed governance. The data dictionary should define each indicator, response scale, coding convention and missing-value rule.
- Distinguish planned, delivered, used and completed activities. For digital tools, distinguish at minimum between registered users, unique active users, completed users/activities and repeated module-level participations.
- For events, distinguish registrations from actual attendance and record onsite and online attendance separately. Where hybrid participation is possible, deduplicate records before reporting the number of unique participants.
- For pre- and post-assessment, calculate learning gain only from valid paired observations. Report the number of learners with both measurements and define explicitly how missing, incomplete and zero values are treated.
- Report both central tendency and distribution for scores where sample size allows. For small samples, report descriptive results cautiously and avoid implying statistical representativeness.
- Record implementation context so cross-country or cross-course comparisons are interpretable. This should include delivery format, target group, institutional context, relevant adaptations and whether participation was compulsory or voluntary.
- Record the date of each analytics extraction and, where systems change over time, retain the relevant version or reporting period.
- Triangulate self-reported feedback with behavioural or performance evidence wherever possible—for example, combine perceived usefulness with platform activity, quiz completion, project assessment or pre/post data.
- Assign a named person or institutional role responsible for each major dataset and define when the data will be collected, checked and reported.
- Apply agreed privacy, retention and access rules to participant-level data and report only aggregated or anonymised results where appropriate.
- Document changes made in response to feedback and test whether they improved results. Maintain a simple improvement log linking identified issue → action taken → evidence reviewed → resulting decision.

15. Conclusions

IGNITE has produced a well-aligned educational concept for STEAM higher education. The learner evidence supports the central design choices: visual explanation, structured progression, personal relevance and practical application. Evidence collected during student workshops further confirms strong acceptance of the nano-learning approach, with the nanomodules receiving an average student rating of 4.50/5. The Virtual Learning Garden and competence-monitoring application were also positively evaluated as components supporting active learning, practice, self-assessment and reflection.

Staff and partner evaluations confirm that the nanomodules, digital application and training are usable, relevant and suitable for further development. The common templates and training also generated valuable capacity among educators and developers. The staff training reached 16 higher-education staff members from all six partner countries, while ten participants completed the formal evaluation, providing evidence of both implementation reach and positive perceived professional relevance.

Implementation evidence strengthens the conclusion that the IGNITE model functions as more than a collection of digital outputs. The Virtual Learning Garden recorded 32 participants, 63 quiz attempts and an average quiz achievement of 80.3%, while the competence-monitoring application recorded 60 registered users, including 44 unique active users engaging with assessments across all ten nano-learning modules.

Challenge-based application was demonstrated through the Innovation Marathon, which produced eight sustainability-oriented student projects compared with the initial target of five. Participant feedback, international jury assessment and the final Scrapbook provide complementary evidence that the approach can connect disciplinary learning with sustainability, innovation, teamwork and communication.

The most important lesson is that effectiveness will depend on integration. The project's tools should function as stages in one learning journey, not as a collection of outputs. Student feedback particularly supports closer technical and pedagogical integration between the application and the Virtual Learning Garden, including simpler onboarding, clearer progression and, where feasible, common login.

The second lesson is that future implementation should continue to strengthen outcome and longitudinal evidence. Positive acceptance is a strong foundation, and the project now also provides evidence of actual platform engagement, project performance and pre-/post-assessment use. However, an overall learner-level competence gain could not be calculated reliably because complete paired pre-/post-assessment data were not available for all users. Longer-term educational transfer and institutional adoption also remain to be assessed through follow-up monitoring.

External stakeholder validation further supports the applicability and transferability of the approach. Across 30 responses from multiplier events and the Final Conference, overall satisfaction reached 4.70/5, while 70% of respondents expressed interest in using or promoting IGNITE results and a further 20% responded "Maybe". This indicates meaningful post-project exploitation potential, particularly for the Nanolearning Modules and Virtual Learning Garden.

With curricular embedding, accessible design, transparent assessment, institutional ownership and a common evaluation protocol, the IGNITE approach can be adapted across STEAM disciplines and

European higher education contexts. Its long-term contribution can be a practical model for connecting sustainability, advanced science, entrepreneurship and learner-centred digital pedagogy. Its sustainability will depend not only on keeping resources online, but on continued course integration, content and platform maintenance, staff ownership, repeated learner use and evidence that external organisations actually adopt or adapt the developed methods.

15.1 Evidence summary

Source	Sample/status	Key evidence used
Empathic Questionnaire Report	108 students; 5 HEIs	Learning preferences, motivation, emotional connection, pacing, digital-video preferences and cross-country differences.
Evaluation of Nanomodules	11 respondents; 5 developers	Development process, template use, video duration, structure, assessment, subtitles, engagement and applicability.
Student Virtual Workshops Evaluation	33 responses; quantitative learner analysis based on 31 students	Direct student evaluation of nanomodules, VLG and application; motivation, usability, learning support and qualitative improvement priorities.
Online Application & Staff Training Evaluation	10 evaluation respondents; staff training reached 16 participants from 6 countries	Application usability, information architecture, self-assessment, usefulness, training quality and open feedback.
Virtual Learning Garden analytics	32 participants; 63 quiz attempts	Actual platform use, active engagement, successful quiz attempts and average achievement of 80.3%.
IGNITE Competence Monitoring Application analytics	60 registered users; 44 unique active users; 70 module-level participations	Assessment uptake across all ten modules, repeated use and available pre-/post-assessment evidence.
Nanomodules Development Guide	Design and production guidance	Structure, learner-centred design, media, interactivity, cultural adaptation, application integration and quality checklist.
Innovation Marathon Organisation Guidelines	Implementation framework	Purpose, KPIs, timeline, roles, student template, mentor guidance and common evaluation framework.
Innovation Marathon participant evaluation	6 respondents	Overall experience, mentoring, collaboration, competence development, final-event quality and qualitative feedback.

Innovation Marathon expert assessment	7 evaluators; 8 student projects	Project quality, innovation, feasibility, sustainability relevance and final project ranking.
Scrapbook of Sustainable Student Innovation Projects	8 documented projects	Evidence of transfer from nano-learning to sustainability-oriented practical application across STEAM fields.
Stakeholder Event Feedback	30 respondents from multiplier events and Final Conference	External validation of relevance, quality, applicability, transferability and future-use potential.

15.2 Recommended nanomodule quality checklist

- The learning outcome is specific, observable and aligned to the wider course.
- The opening establishes relevance through a real problem, scenario or decision.
- The explanation uses a clear visual model and logical progression.
- Narration, on-screen text and visuals reinforce rather than duplicate one another.
- Pacing allows comprehension; key terms are introduced and revisited.
- At least one practical, interactive or reflective action is included.
- Assessment items measure the stated outcome and provide explanatory feedback.
- Captions, transcript, contrast, text size and alternative access are checked.
- Mobile usability and display across different screen sizes are tested.
- Audio quality, pronunciation, branding, references and scientific accuracy are reviewed.
- The learner can see the previous step, next step and expected completion time.
- Links between the nanomodule, VLG activities and competence assessment are tested and clearly signposted.
- The learner is informed how the module contributes to the wider learning pathway and what activity should follow completion.
- The module has an owner, version, review date and update procedure.

15.3 Recommended Innovation Marathon rubric anchors

The existing 100-point weighting should be retained, with anchored descriptors added to improve consistency. Future implementation should also include a short evaluator-calibration exercise before scoring, retain criterion-level comments, and define in advance how missing evaluator scores will be handled when calculating final results. The following summary illustrates the expected distinction between performance levels.

Criterion	Excellent	Adequate	Needs development
Challenge relevance	Specific, evidence-based and societally significant.	Relevant but evidence or scope is partial.	Vague, weakly evidenced or disconnected from sustainability.
Methodology	Coherent, rigorous, feasible and transparently documented.	Generally appropriate with minor gaps.	Unclear, infeasible or unsupported.

Innovation	Clear novelty or valuable adaptation with comparison to alternatives.	Some new combination or contextual value.	Novelty asserted but not demonstrated.
Feasibility and impact	Credible pathway, assumptions, risks and measurable benefits.	Potential is plausible but incompletely tested.	Impact claims are unsupported or implementation is unrealistic.
Presentation/report	Clear, concise, evidence-led and professionally communicated.	Understandable with minor structural or evidence gaps.	Difficult to follow or inadequately documented.
Teamwork/communication	Roles, collaboration and stakeholder communication are evidenced.	Collaboration is adequate but unevenly evidenced.	Roles or communication problems materially affect delivery.

15.4 Evaluation instruments

The following project instruments are referenced in the report and remain part of the project evidence archive:

- IGNITE Nanomodules Development Guide
- Evaluation of IGNITE Nanomodules
- IGNITE Evaluation – Online Application & Staff Training
- IGNITE Empathic Questionnaire Report
- Student Virtual Workshops Evaluation Questionnaire and consolidated responses
- Virtual Learning Garden analytics and system overview
- IGNITE Competence Monitoring Application analytics and pre-/post-assessment outputs
- IGNITE Innovation Marathon Student Project Evaluation
- Innovation Marathon Participant Evaluation Questionnaire
- Innovation Marathon international jury assessment results
- Scrapbook of Sustainable Student Innovation Projects
- Stakeholder Event Feedback Questionnaire – National Multiplier Events and Final Conference
- National multiplier-event reports, participant evidence and Final Conference documentation
- An Integrated Framework of Nano-Learning, Gamification and Challenge-Based Learning for Sustainable Innovation in Higher Education
- The Role of Scientific Empathy and Learning Preferences in Shaping Innovative and Sustainable Learning in European Higher Education

15.5 Remaining evidence limitations and follow-up priorities

Remaining limitation / evidence need	Recommended follow-up	Purpose
Complete paired competence-development data	Enable export of anonymised paired pre-/post-assessment records and clearly distinguish missing, incomplete and zero values.	Calculate reliable learner-level and module-level learning gain and examine outcome distributions.
Longitudinal learner engagement	Monitor return use, repeated module participation and independent use beyond facilitated workshops.	Determine whether initial engagement develops into sustained learning behaviour.
Longer-term educational adoption	Conduct educator and learner follow-up after 8–12 weeks and, where feasible, again after 6–12 months.	Assess transfer into teaching, learning and professional practice.
Institutional exploitation evidence	Follow up with stakeholders who expressed interest in future use and document actual course integration, adaptation or reuse.	Distinguish stated future intention from demonstrated adoption.
Consistent event participation evidence	Use common attendance templates and distinguish registrations, onsite attendance, online attendance and unique participants.	Improve comparability and reliability of future dissemination and multiplier-event KPIs.
Cross-platform learner analytics	Develop a common or interoperable monitoring approach across the application, VLG and related learning environments.	Analyse the complete learning pathway rather than isolated platform activity.
Accessibility and inclusion evidence	Conduct structured testing with different devices, assistive technologies and users with different levels of digital confidence.	Verify that technical availability translates into equitable usability.

References and Supporting Evidence

Project documents and evaluation sources

The evaluation presented in this report is based on project documentation, evaluation instruments, learning analytics, participant feedback and expert assessment generated during the implementation of the IGNITE project. The principal evidence sources include:

- IGNITE Empathic Questionnaire Report
- IGNITE Nanomodules Development Guide
- Evaluation of IGNITE Nanomodules
- IGNITE Virtual Learning Garden Overview and Learning Analytics
- IGNITE Evaluation – Online Application & Staff Training Report
- IGNITE Competence Monitoring Application – User and Pre-/Post-Assessment Analytics
- Student Virtual Workshops Evaluation Questionnaire and Consolidated Results
- International Virtual Workshop agendas, reports and participant documentation
- IGNITE Innovation Marathon Guidelines and Implementation Procedure
- IGNITE Innovation Marathon Student Project Evaluation
- Innovation Marathon Participant Evaluation Questionnaire and Consolidated Results
- Innovation Marathon International Jury Evaluation Results
- Scrapbook of Sustainable Student Innovation Projects
- Stakeholder Event Feedback Questionnaire and Consolidated Results – National Multiplier Events and Final Conference
- National Multiplier Event reports, agendas and participation evidence
- IGNITE Final Conference Programme, registration and participation evidence

Supporting implementation evidence, including agendas, participant and attendance lists, certificates, photographs, screenshots, questionnaire datasets, learning-platform analytics and other project monitoring documentation, is retained in the IGNITE project evidence archive and is not reproduced in this report in order to avoid unnecessary duplication and to protect personal data.

Scientific and methodological references

- Abina, A., Zidanšek, A., Temeljotov Salaj, A., Diaconu, M. G., Canal, C., Tampieri, F., Nikiforov, A., Morent, R., Banderova, T., Nomine, A., & Puc, U. (2026). The role of scientific empathy and learning preferences in shaping innovative and sustainable learning in European higher education. *Journal of Sustainable Development of Energy, Water and Environment Systems, 14*(4), 1140726. https://doi.org/10.13044/j.sdewes.d14.0726
- Abina, A., Kovačič, D., Gamse, B., Temeljotov Salaj, A., Adhikari, A., Diaconu, M. G., Rogge, V., Canal, C., Tampieri, F., Nikiforov, A., Leus, K., Banderova, T., Nomine, A., Cvelbar, U., & Zidanšek, A. (2026, August 30–September 3). *An integrated framework of nano-learning, gamification and challenge-based learning for sustainable innovation in higher education*. 21st Conference on Sustainable Development of Energy, Water and Environment Systems (SDEWES), Gran Canaria, Spain.
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