Report 4

Evaluation and good practices on introducing technology in practice placement - Pilot study results

Digitalization in learning practice placement

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Title: Report 4. Evaluation and good practices on introducing technology in practice placement - Pilot study results

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The 4D project is an EC-funded project (February 2022 to February 2025) to introduce mobile technology in practice placements, creating a bridge between the different actors involved learning contexts to foster the best experience in practice-based learning in healthcare settings. Our multidisciplinary team uses qualitative, quantitative and designs methods in order to help European Universities that are interested in introducing mobile applications in practice placements to design the best mobile app proposals based on the different actors involved (students, clinical and academic tutors, managers, and others) from different contexts (universities and centers of practices).

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Find out more: https://4d.tecnocampus.cat/

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Content

Executive Summary **7**
1. Introduction **10**
2. Background **12**
2.1. Key factors for Successful Digitalization of Practice-based Learning 12
2.2. Recommendations to ensure the introduction of mobile technology in practice placements settings 13
2.3. Co-Design of Learning Toolbox and Learning Goal Widget 14
3. Introducing Technology in practice placement **17**
3.1. Adoption of mobile technology in practice-based learning 17
3.1.1. Designing the Technology 17
3.1.2. Developing teaching resources 20
3.1.3. Implementing the Technology 22
3.2. Development of training material to introduce technology in practice-based learning 22
4. Identification of strengths, weaknesses, opportunities and threats of the diversity of the different practice placements and adoption of mobile technology **24**
4.1. Knowledge base on organizational diversity (SWOT) 25
4.2. Consensus on personalized mobile applications **25**
4.3. Sharing best practices 26
4.4. Reflection on mobile app use 26
5. Pilot-Study **29**
5.1. Background 29
5.1.1. Background and rationale 29
5.1.2. Rationale for the study 30
5.1.3. Objectives of the study 30
5.1.4. Theoretical frameworks 31
5.2. Methodology 31
5.2.1. Study design including participants and sampling 31
5.2.2. Data collection instruments 32
5.2.3. Data Analysis 33
5.2.4. Ethical consideration 34
5.3. Results of the pilot-study 34
5.3.1. Pre-questionnaire 34
5.3.1.1. Demographics and experience 34
5.3.1.2. Affinity for Technology Interaction 34
5.3.1.3. Expectations 34
5.3.2. Post-questionnaire 37
5.3.2.1. Numbers, demographics & pre knowledge 37
5.3.2.2. Learning Toolbox (4D Mobile Apps & the LTB stacks) 37
5.3.2.3. Learning Goal Widget (LGW) 39
5.3.2.4. Comprehensive Summary of results & Limitations 44
5.4. Short summary of the pre-questionnaire 46
5.5. Short summary of the post-questionnaire 46
6. Project Results from Work Package 4 **48**
6.1. Recommendations 50
7. References **52**

Executive Summary

This report provides the results of work package 4 called "Evaluation and good practices on introducing technology in practice placement". Its aim is to evaluate and approve the initial pilot results and toolkit for adopting mobile technology in practice-based learning within the Project '4D Digitalization in learning practice placement'.

The report first summarizes the development and implementation of the 4D Mobile Apps, which were developed using Learning Toolbox (LTB) and included the Learning Goal Widget (LGW). Afterwards, the report describes the evaluation of the 4D Mobile Apps for the three primary objectives enhancing onboarding processes, supporting reflective practices, and facilitating self-assessment and learning goal tracking for healthcare students during practice placement. The pilot study was conducted across three European educational institutions — School of Health Sciences TecnoCampus Mataró-Maresme Spain (TCM), Medical University Lublin (MUL), and Medical Faculty of the University Duisburg-Essen (UDE) — to assess the usability, effectiveness, and overall impact on the clinical education experience.

The results of the pilot study demonstrated both successes and challenges in using the 4D Mobile Apps and LGW to improve clinical education:

- **4D Mobile Apps & LGW:**
  - Both tools were positively received for streamlining the onboarding process, offering organized access to essential resources, and supporting structured reflection and feedback.
  - Students valued the features for promoting self-directed learning and providing structured, accessible resources that could support them in clinical practice.
- **4D Mobile Apps:** They offer easy access to learning materials, schedules, and contact information.
- **Learning Goal Widget (LGW):** The tool motivated for self-assessment aligned with specific learning goals.

However, several challenges emerged and pointed to areas for improvement:

- **Overall satisfaction and engagement:** Some usability issues including complex navigation, limited user-friendliness, and inconsistent use of the technology should be improved.
- **Mentor engagement:** The tools revealed a need for better mentor engagement and consistent feedback, as mentors' involvement and comfort with the digital tools varied, limiting their effectiveness in certain placements.
- **Self-assessment:** LGW was intended to improve self-regulation by enhancing learning goal tracking, but some students found the self-assessment feature difficult to integrate into their clinical routines.

The SWOT analysis by the first users underscored diverse strengths, weaknesses, opportunities, and threats at each participating institution. For instance, strengths included strong infrastructural support whereas staffing variability impacted consistent mentorship. Digitalization was seen as a major opportunity across institutions, with the potential to standardize educational quality. However, external factors, such as staff shortages and time constraints in clinical settings, presented threats that limited the tools' widespread adoption and effective use.

Based on the results of the pilot study, the report provides several recommendations:

1. Usability should be improved by simplifying the 4D Mobile Apps (the LTB stacks) and LGW interfaces, addressing feedback on navigation challenges and functionality.

2. Enhanced mentor training on digital engagement would also ensure that clinical tutors are fully equipped to use the apps and provide timely, structured feedback.
3. In addition, creating more intuitive self-assessment tools and integrating practical learning objectives closely aligned with clinical tasks can make these digital tools more valuable to both students and mentors.
4. Technical improvements, such as offline access and seamless data synchronization, would also support better usability in clinical settings where connectivity may be limited.

In summary, while the 4D project has made significant strides in supporting digital learning in healthcare education across learning contexts, the pilot study suggests that further refinements to the 4D Mobile Apps (the LTB stacks) and LGW are necessary to fully realize their potential. The project highlights the critical role of structured onboarding, reflective practice, and mentorship in clinical learning and underscores the importance of adaptive, user-friendly technology in achieving these educational goals. These insights offer a roadmap for future digitalization efforts in healthcare education, ultimately aiming to create a more effective, scalable model for digital supported clinical learning that bridges theoretical knowledge with practical skills.

1. Introduction

Introducing mobile technology into clinical education within practice placements has the potential to significantly enhance the learning experience, improve knowledge retention, and help students develop clinical skills, all while offering a cost-effective solution for clinical education programs. However, the learning process in clinical settings is complex and involves multiple stakeholders, such as tutors, supervisors, teachers, and students. During this process, tasks and mentorship must be synchronized with both educational and clinical workflows to ensure successful integration.

The 4D project (Determinants, Design, Digitalization, Dissemination) focuses on the digitalization of learning in practice placements, funded by the European Commission. Its primary goal is to introduce mobile technology into practice placements, thereby creating a bridge between the various actors involved in learning contexts and fostering an improved practice-based learning experience in healthcare settings (Martínez-Gaitero, et al., 2023). The 4D project aims to achieve this by implementing five key objectives:

- **Determine** the key factors (practice-based learning models) and core elements (such as diffusion of innovation theories) that will facilitate the introduction of mobile technology into practice placements.
- **Co-design** a mobile learning application (app) that reflects the core values and needs of users, ensuring the successful adoption of mobile technology in practice-based learning.
- **Introduce digitalization** by training participating institutions through workshops and tutorials, equipping them with the necessary skills to implement mobile technology effectively.
- **Pilot and assess** the use of mobile learning in healthcare higher education practice placements across three European countries.
- **Disseminate** the project findings as part of an inclusive approach to support and exchange knowledge regarding the digitalization of practice placements within universities across EU countries.

The findings from Reports 1 (Huertas et al., 2023) and 2 (Dobrowolska et al., 2023), which identified the key factors and core elements essential for facilitating the introduction of mobile technology into practice placements, along with the insights from Report 3 (Fessl et al., 2023), which focused on the co-design of a mobile learning application that aligns with the core values and needs of users, were thoroughly analyzed. These results were carefully integrated into the design of the methodology and research framework for assessing the feasibility of the pilot study in this Report 4.

This report summaries the results of work package 4 (WP 4) called “Digitalisation of practice placements. Evaluation and good practices”.

In this regard the objectives of WP4 were defined in the proposal as follows:

- Design the methodological and research aspects of the feasibility study
- Validate the digital contents with the other partners involved in the pilot study
- Organize complementary activities as additional training, organization support, conference calls, and complementary materials
- Provide recommendations in Project results.

In clinical practice placements, learning processes, tasks and mentorships must be carried out in a way that it is coordinated with educational and clinical processes and entrenched in the appropriate contexts.

2. Background

2.1. Key factors for Successful Digitalization of Practice-based Learning

The aim of work package (WP) 2 of the Project was to describe the key factors of various models and theories related to practice-based learning and to identify the main elements necessary for introducing mobile technology into clinical education. Specifically, it focuses on identifying and analyzing the primary facilitators and barriers while addressing the needs and perspectives of healthcare students and stakeholders involved in clinical education.

To achieve the report's objectives, a literature review and focus groups with healthcare students and stakeholders were conducted.

Numerous facilitators were identified as:

- **Positive Attitude towards Mobile Applications:**
  Students, educators, staff, and patients generally view mobile learning positively in clinical education. Mobile devices are seen as helpful for learning and practice, with students preferring them over textbooks for their convenience and entertainment value.
- **Improving Clinical Education Quality**
  Mobile technology enhances clinical education by facilitating learning, supporting target-oriented study, and inspiring cognitive engagement. It aids students in testing their knowledge and skills, boosting clinical competency, confidence, and self-efficacy. Mobile devices provide quick, centralized access to up-to-date information anytime and anywhere.
- **Managing the Learning Process**
  Mobile devices allow for tracking student progress against curriculum goals, helping identify areas for improvement. Educators can also provide timely support, manage materials, and promote student self-organization, which supports better work-life balance.
- **Enhancing Communication and Cooperation**
  Smartphones improve communication and collaboration with peers, teachers, mentors, and staff. Staying connected with the university and colleagues helps students feel supported and less isolated during clinical placements.
- **Benefits for Patient Care**
  Mobile devices reduce errors, enhance evidence-based practices, and improve diagnostic accuracy. They engage patients in their care and aid in patient education, promoting safe and reflective clinical practice.
- **Practical Benefits**
  Mobile devices provide easy access to all documents in a single location, portability, user-friendliness, and immediacy, which students find valuable. They also save on printing costs and time, making clinical tasks more efficient.

There were also significant concerns and challenges that need to be addressed when introducing mobile technology into clinical education. Key issues identified include:

- **Lack of clear regulations and guidelines:** Using mobile devices as learning tools in clinical settings is not yet formalized. Many medical schools do not permit mobile devices in clinical settings, and healthcare policies regarding their use are inconsistent. Furthermore, there is a lack of clear instructions on how mobile devices can be integrated into students' learning activities. Infection control policies regarding mobile devices are also unclear.
- **Low cultural acceptance in clinical settings:** There is generally a lack of cultural acceptance for using mobile devices for scientific and educational purposes in clinical environments. Teachers, patients, and staff—especially senior staff and ward management—often disapprove of students using devices, assuming they are for personal use rather than educational purposes. Students also feel uncomfortable using mobile devices in front of patients due to perceptions of unprofessionalism.

- **Ethical, privacy, and security concerns:** Issues related to confidentiality, privacy, and patient security arise when students use personal phones in clinical settings. The use of mobile technology may also negatively affect patient interactions, including communication, care perception, and the compassion exhibited by healthcare providers.
- **Negative impact on practice and learning:** The potential for distraction when using mobile devices was identified as a significant barrier. This distraction can impede the learning process, weaken the relationship between students and clinical mentors, and hinder observation-based learning. It can also present risks to patients by reducing interpersonal communication and eye contact during patient care.
- **Technical issues, costs, and inadequate infrastructure:** Technical challenges include limited battery life, small screens, complicated interfaces, insufficient device memory, and unreliable internet connections—especially in resource-limited settings. Additionally, many clinical environments do not allow students to use their Wi-Fi networks. Other issues include problems with data synchronization across different mobile devices, limited software and hardware functionality compared to computers, a lack of technical support, and concerns regarding theft, damage, contamination, and the costs of devices and applications.
- **Information literacy and digital competences:** Some students and mentors face barriers related to digital literacy and skills, such as a lack of fluency in English for scientific content, limited experience using mobile devices, and inadequate training and support.

From these findings, several key areas have been distilled to inform the co-design of a mobile learning application. This app must reflect users' core values and needs to ensure the successful adoption of mobile technology in practice-based learning. By addressing the challenges and leveraging the identified facilitators, educators and other stakeholders can develop effective, innovative digital learning strategies that enhance the quality of healthcare education. (Huerta A, et al., 2023)

2.2. Recommendations to ensure the introduction of mobile technology in practice placements settings

The recommendations for introducing mobile technology into practice placements outline focusing on three key stages: designing the technology, implementing it, and ensuring its sustainability after adoption.

Designing the Technology

When designing mobile technology for practice placements, several factors must be considered. One of the most important aspects is the cost of developing and implementing the technology. Institutions need to ensure that any investment is cost-effective and delivers value in terms of student learning outcomes and healthcare results. Careful budgeting should account for devices, maintenance, support, and internet connectivity.

Technically, the mobile learning platform should offer features such as offline storage, easy access to content, and compatibility across devices. The technology must function seamlessly, providing adequate memory, fast software performance, and the ability to transfer data between different devices. It is also critical to ensure that the mobile technology provides strong data protection, with secure storage and transmission of information, especially given the sensitive nature of patient data. Clear guidelines should be established for data security and privacy.

Selecting the appropriate device for students is crucial. The choice between tablets and smartphones depends on the context in which the technology will be used. The device should be practical and easy

to carry while fitting the needs of students in various clinical settings. Additionally, mobile learning platforms must engage both students and educators by providing interactive and motivational learning activities. To ensure the technology meets its goals, the design should reflect the learning needs and preferences of its users, making it not only functional but engaging.

Implementing the Technology

The successful implementation of mobile technology in practice placements requires careful planning and support. Training plays a key role, as students, educators, and clinical staff need to develop the digital competencies necessary to use the technology effectively. Offering workshops and resources on navigating mobile platforms and addressing privacy and security concerns will help users gain confidence.

An implementation team can support the roll-out of the mobile learning platform by providing technical expertise, project management, and user support. This team will ensure that the technology is deployed effectively and that any challenges are addressed in a timely manner. Furthermore, creating a culture that embraces mobile technology is essential. Students and staff should be encouraged to see mobile technology as a valuable tool for learning and improving care. Clear communication with patients regarding the use of mobile devices in clinical settings is also important to avoid misunderstandings.

Ensuring Sustainability

To sustain mobile technology in practice placements over the long term, institutions must provide ongoing technical and maintenance support. This includes ensuring that devices, software, and connectivity are reliable and up to date. Additionally, institutions should guarantee that students and educators have access to mobile devices and offer support for lost or damaged equipment.

A robust infrastructure is essential for the continued use of mobile learning. Free and reliable internet access in clinical settings is crucial for ensuring that students can use mobile technology effectively. Finally, regular feedback from students and stakeholders should be gathered to assess how well the technology is working and to make necessary adjustments. Continuous evaluation will help improve the technology and ensure that it remains effective in meeting the learning needs of its users.

Conclusion

Introducing mobile technology into clinical education can enhance the learning experience, but several factors must be carefully managed to ensure its success. Effective design should account for costs, technical requirements, and security, while implementation requires thorough training and support from all stakeholders. For the long-term sustainability of mobile learning, institutions need to provide technical support, maintain infrastructure, and gather feedback regularly (4D Project Team, 2023).

2.3. Co-Design of Learning Toolbox and Learning Goal Widget

The aim of work package 3 (WP3), titled “Co-creation and Co-design” was to “Determine the Key Components of the App (4D Mobile Apps (the LTB stacks) and LGW) in Practice-Based Learning.” The learning process in clinical practice placements involves various stakeholders, including students, clinical tutors, academic assessors, link teachers, and managers. These tasks and mentorship roles must be carefully coordinated with educational and clinical processes and rooted within the appropriate context.

WP3 was responsible for defining and conducting co-creation and co-design activities with all project partners to identify the key components and features of potential mobile applications. The goal of these applications is to support all stakeholders in facilitating student learning in practice-based environments, considering multiple perspectives. The objectives of WP3 were outlined as follows:

- **Introduce co-design and co-creation** as methods to ensure continuous active participation from participants in the design process for educational innovations, especially those involving technology as a crucial support in practice placements.
- **Emphasize user-centered methods** and scenario-based design approaches to improve usability in practice-based learning contexts.
- **Promote learner-centered design** in workplace learning to motivate students to utilize mobile learning in practice settings.
- **Develop mobile workplace learning technology** that reflects the core values and needs of users to encourage successful adoption in practice placements.
- **Track the co-design and co-creation process** in design trajectories, capturing all design artifacts generated to enable insights beyond their use in our specific designs.
- **Provide a recommendations toolkit** to facilitate the introduction of mobile technology in various higher education scenarios across the EU, titled 'A toolkit to introduce mobile technology in practice placements in higher education in the EU countries.'

The entire co-creation and co-design process involved all project partners and key stakeholders, ensuring that the resulting mobile technologies were well-suited to the learning needs of students in practice placements. The process followed seven distinct steps, employing various design methods and tools such as the university innovation canvas (based on the business model canvas), which was used as a central tool throughout the design process. Additional tools included the value proposition canvas, personas, scenarios, user journeys, and mock-up development.

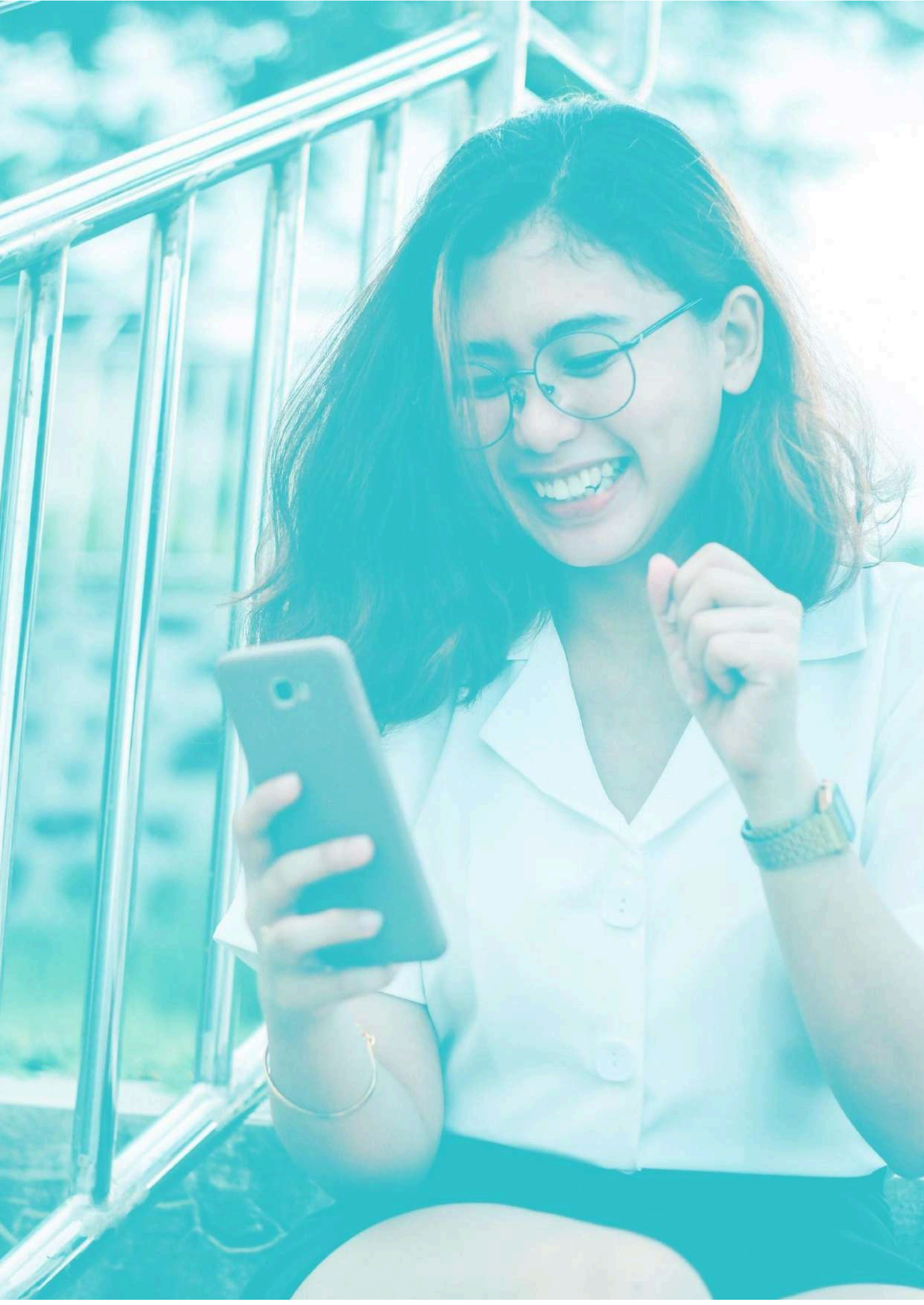
The co-design process led to the development of three distinct design trajectories:

Trajectory 1: Onboarding, Communication, and Documentation – Focused on providing onboarding materials, documentation, and communication channels to ensure easy access to the right personnel.

Trajectory 2: Reflective Practice and Feedback – Designed to offer a mini-guide within the mobile app to facilitate feedback and support both individual and collaborative reflection on learning tasks and activities.

Trajectory 3: Assessment and Learning Goals – Aimed at presenting clearly formulated learning goals tied to the relevant curriculum for practice placements.

These three trajectories were implemented using two applications: the Learning Toolbox (https://ltb.io/) and the prototypical Learning Goal Widget (https://4dhostings.tecnocampus.cat). Together with these design trajectories, the recommendations toolkit ensures that the insights and tools developed in the 4D project can be applied to introduce mobile technology in various scenarios and contexts within higher education (Fessl et al.,2023)



3. Introducing Technology in practice placement

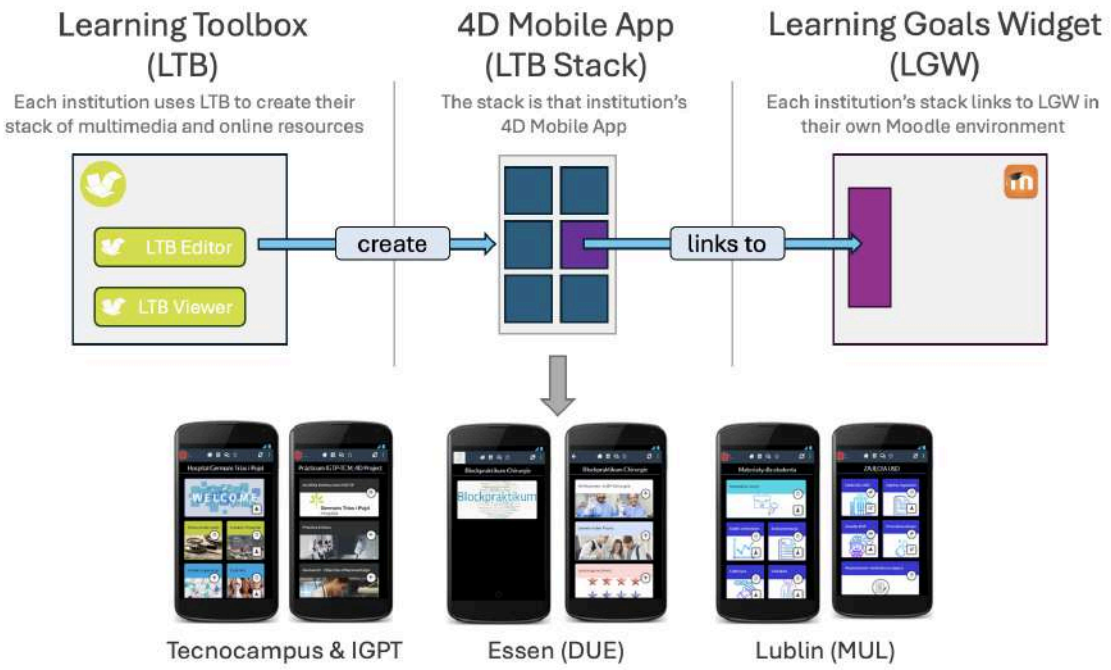
3.1. Adoption of mobile technology in practice-based learning

3.1.1. Designing the Technology

The integration of mobile technology into practice placements followed a structured approach, focusing on three key phases: technology design, development of teaching resources, and ensuring sustainable implementation. To achieve this, project partners opted for a cost-effective, easily maintainable tool, addressing challenges at practice sites.

The selected tool, Learning Toolbox (LTB), provides multi-device access via smartphones, tablets, laptops, and desktops https://ltb.io. Emphasis was placed on ensuring seamless content retrieval and compatibility with platforms like Moodle. Data protection and privacy standards were prioritized during the design process.

Through collaboration between the School of Health Sciences TecnoCampus Mataró-Maresme . Spain (TCM), Medical University Lublin (MUL), and Medical Faculty of the University Duisburg-Essen (UDE), a mobile application was developed for each practice placement using LTB and the Learning Goals Widget (LGW) (Picture 1).



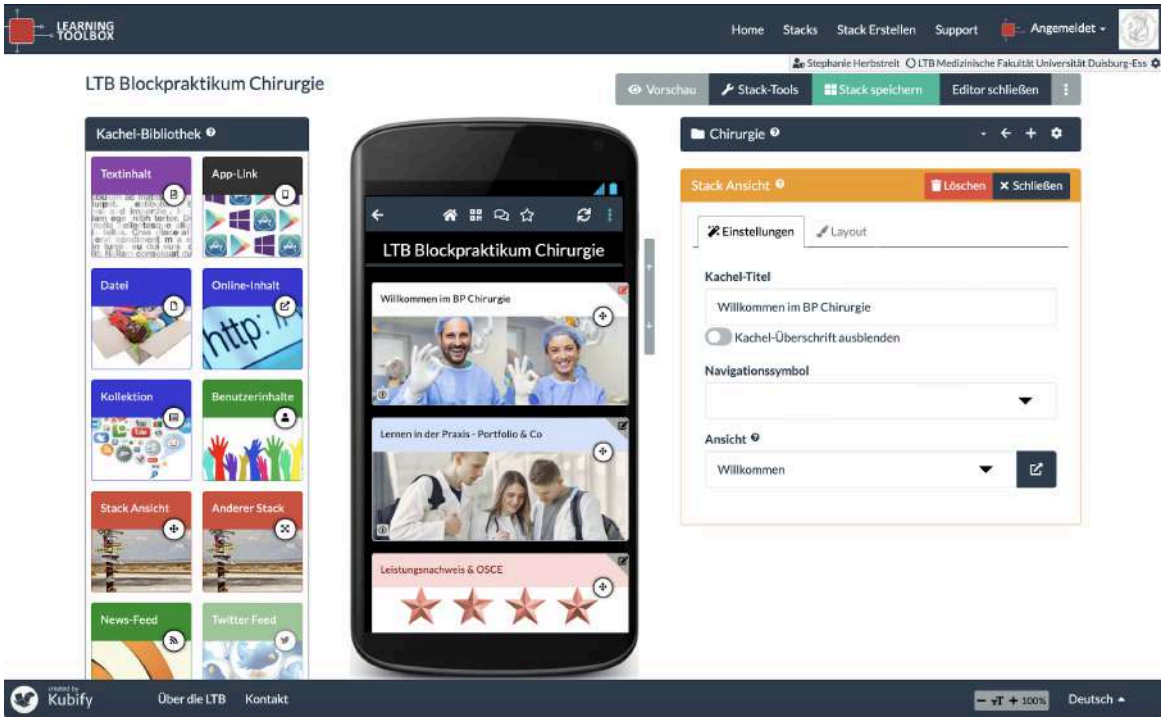
Picture 1: Integration of the software development of the digital tools

Each app supports teaching and learning across various placements by offering onboarding, communication, documentation materials and assessment function, as well as self-assessment possibilities, during the practice placement. It also includes personalized mini-guides for reflection and feedback, enhancing the learning experience for students and the teaching experience for clinical tutors. The design aimed to create a functional and engaging platform that fosters interaction and reflection on learning tasks and activities (Fessl et al.,2023).

Learning Toolbox

The 4D project used Learning Toolbox (LTB) to develop the 4D Mobile Apps. LTB is a commercial platform developed and owned by Kubify, which is used both within education and events to support the easy creation and sharing of "stacks" of multimedia and online content. The stacks are designed to be viewed in the LTB App on mobile devices but can also be viewed in any web browser on any internet-connected device.

Authors use the LTB editor to create stacks and can add and arrange a wide range of multimedia and online resources into the stack. Each resource appears as a tile in the stack (Picture 2).



Picture 2: Design interface of Learning Toolbox of Kubify at UDE

Each stack has its own unique QR code and web link. For users each stack, when opened on their phone, has the appearance of an App and they can navigate it by clicking on the different tiles that the author has added to the stack. Additionally each stack has its own chat area where public messages can be posted and email notifications (of new messages) set-up.

The team at Kubify (https://kubify.co) trained and supported the 4D pilot partners in creating their stacks (the 4D Mobile Apps) using **Learning Toolbox (LTB)** An initial in-person training session was held during the onsite project meeting in Lublin. During the development stage, multiple online sessions were conducted to support the teams responsible for developing the mobile apps for their specific practice placements. These sessions were tailored to address the individual needs of each team member, ensuring the apps met the unique requirements of their practice environments. The sessions also encouraged partners to share their developments and discuss and learn from each other's approaches.

More information about how LTB can be used to create stacks can be found in the 4D Recommendations Toolkit (https://api.ltb.io/show/ABYDG) or on the 4D website (https://4d.tecnocampus.cat/toolkit/).

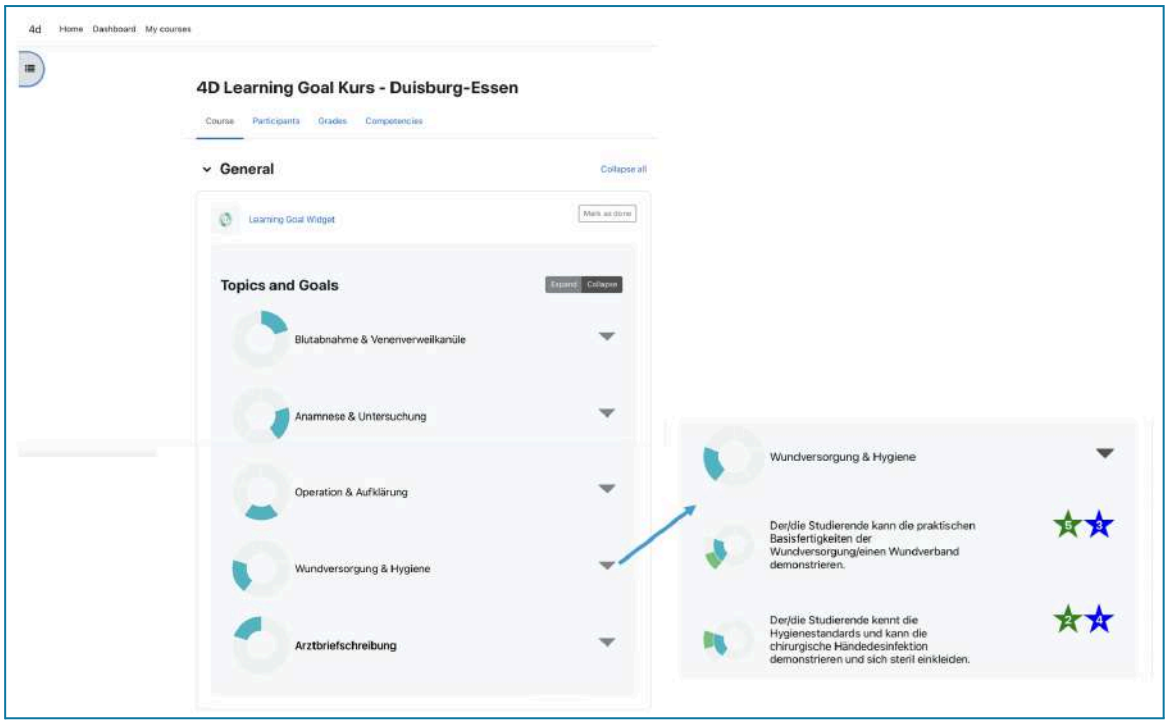
Learning goal Widget

The **Learning Goal Widget (LGW)** was developed as part of the 4D project to help track and assess student progress during practice placements empowering students to better regulate their learning process with the nurse or clinical mentor and university teacher. It was created using mock-ups from a co-design process and integrates features from previous projects such as the Erasmus+, project DIGIVID (https://digivid.isds.tugraz.at) and the Technology Enhance Learning TEL Marketplace (https://www.tugraz.at/institute/isds/research/projects/digitale-tu-graz-marketplace). The widget is implemented as a Moodle activity and is used in three different courses, one for each practice placement.

The LGW provides two main views—one for nurses/clinical mentors and one for students. In both views, users can access an overview of the topics and learning goals for each placement (Picture 3). Students can click on specific learning goals to access detailed descriptions in PDF format, along with additional learning materials uploaded by educators. This allows the students to understand what a learning goal means and how it can be approached in the placement.

A key feature of the LGW is the student self-assessment tool. Students can assess their progress toward each learning goal by rating themselves on a scale from 1 to 5 stars. They also have the option to indicate if a particular goal was not taught or practiced during the placement. Nurses and clinical mentors also play a role in the assessment process. After selecting a student, they can evaluate the student's performance on each learning goal, using the same 1 to 5-star rating system. Additionally, they can note if a goal was not covered during the placement. Immediate feedback from nurses and clinical mentors on their self-assessment allows students to correct wrong assumptions and regulate their learning in terms of consulting lecture materials or more training, for example. Noting not addressed learning goals additionally raises the university teachers' awareness to learning goals that could not be addressed in a placement. At the end of the practice placement, nurses can provide a final assessment of the student's progress. This includes a summary of all ratings and additional feedback, which can be saved as a PDF report.

In essence, the LGW offers a structured and interactive approach for both students and nurses/clinical mentors to monitor and evaluate learning progress during clinical practice placements (Fessl et al.,2023).



Picture 3: interface of Learning Goal Widget of TU Graz

3.1.2. Developing teaching resources

Teaching resources were developed and integrated in the 4D Mobile Apps (the LTB stacks) for all practice placements. Following the co-creation and co-design process the within this process created material was used by each partner, as there was the 4D Feedback Mini Guide, the 4D reflective practice and the 'learning goal design'.

Feedback mini-guide

The **4D Feedback Mini Guide** is a resource designed to enhance learning and professional growth in healthcare by emphasizing the importance of feedback. It offers practical strategies for clinical mentors and students, highlighting feedback as a key tool for improving clinical competence and teamwork.

Effective feedback should focus on specific behaviors, combining positive reinforcement with constructive criticism. The guide introduces techniques like the Sandwich Technique (positive-critique-positive), Cookie-Lemon-Cookie and the Pendleton Model, where students first evaluate themselves before receiving feedback. Good feedback is timely, specific, and actionable, while vague or overly critical feedback is less effective. Clinical mentors play a crucial role in providing feedback during practice placements. Feedback should be clear, objective, and focused on both strengths and areas for improvement. Mentors should guide students in setting goals, improving skills, and supporting their professional development.

The guide also provides examples of feedback tailored to learning goals such as clinical skills, communication, and teamwork. Overall, it emphasizes the importance of well-structured, constructive feedback for fostering student growth in healthcare settings (Martínez-Gaitero, et al., 2023).

Reflective Practice Mini Guide

The 4D Reflective Practice Mini Guide supports students and clinical tutors in implementing reflective practice in healthcare. It emphasizes reflection for personal and professional growth and offers two key methods:

- **STARRT Method:** A step-by-step approach where students reflect on caregiving experiences by describing the situation, defining goals, evaluating actions, and applying insights as reflecting on "Situation, Task, Action, Result, Reflection, and Transfer" of a learning experience.
- **Experiential Learning:** Combines hands-on practice with reflection through narration and analysis of learning outcomes.

The guide provides tools to help students assess their strengths and areas for improvement, fostering continuous growth and preparing them for future clinical challenges (Martínez-Gaitero, et al.,2023.

Learning goals design

With the help of the partners of work package 3 researchers of each partner institution were trained and instructed to design, develop, and implement learning goals and outcomes in educational settings, particularly emphasizing their collaborative creation in a systematic way. In this project, learning goals and outcomes different in terms of their scope: On level of a lecture, learning goals define what students are expected to know, understand, and do by the end of a course and/or practice placement. They are measurable, specific, and guide assessments and instructional activities. These goals should match the learners' level and inform both the curriculum design and student evaluations. On the level of learning activities, intended learning outcomes focused on what students should know and demonstrate after completing the activity. They include not only the content to be learned but also how it should be learned and the expected standards of performance. Intended learning outcomes are therefore more specific and integrated in more general learning goals.

Learning goals should be specific, using action verbs to clarify what students should achieve, for example, moving from general goals like "understanding a topic" to measurable tasks like "performing a venipuncture." Different levels of learners—novices, competent learners, advanced beginners, and experts—have different needs. Novices need structured guidance, whereas experts are more self-directed and seek innovation and collaboration. Understanding the level of the learner helps in designing appropriate goals. The concept of Constructive Alignment asks for designing learning goals, assessment tasks, and instructional activities. Learning goals direct what assessments should be measured and what activities should support achieving those goals. One should start with the learning outcomes, then construct assessments and finally design activities accordingly.

With help of an introduced **Learning Goal Tool** (Hirose et al. 2022) and the described systematics for defining well-formulated learning goals described in Fessl et al. 2021, educators were supported to systematically design learning goals, specifying the time frame, level of the learner, and actions to be performed. This tool was interactive, allowing for automatic translations and the systematic formulation of goals based on knowledge versus application levels.

Collaborative Design Process

A collaborative process in defining learning components, specifying learning goals, and using tools to ensure clarity and alignment can ensure that goals are shared and appropriately tailored to specific educational contexts (Fessl et al., 2023).

3.1.3. Implementing the Technology

Effective implementation requires thorough planning and support. Training workshops and resources were planned to help students, educators, and staff develop the necessary digital skills taking into account the key factors detected in PR1 for successful digitalization of practice-based learning. An implementation team managed technical support and project oversight, addressing any challenges that arise at each practice placement. Cultivating a culture that values mobile technology is important for its adoption, and clear communication with stakeholders and patients is crucial to avoid misunderstandings.

3.2. Development of training material to introduce technology in practice-based learning

After the creation of the individual mobile application for each practical placement the introduction of these apps and Learning Toolbox (LTB) in the context of practice placement became necessary.

Training material for each practice placement was created to help students, educators and staff to introduce the LTB to the future users and to help to navigate through the material. Beside the provided content and the different support within the apps to create a deeper, sustainable learning the training material also provided technical support.

This material introduces students and mentors to the Learning Toolbox, providing a clear overview of how to install and use the platform and highlighting the key benefits for clinical education in surgical practice.

The training material was introduced before the course to the students in introductions seminars of the practice placement and to mentors during individual or group training that was initiated before the practice placement startet. The following important aspects were taken into account:

Introduction to the Learning Toolbox (LTB) for practice placement

The innovative digital platform was introduced to be designed to enhance clinical education experience in the practical environment. The 4D Mobile Apps (the LTB stacks) provide a structured approach to learning by offering easy access to resources, tools, and support, helping achieve key competencies of the practice placement. The training material was designed to introduce users to the purpose of the LTB, how to use it, and its benefits for both students and mentors in clinical practice.

Purpose of the Learning Toolbox (LTB) in Practice placement

The 4D Mobile Apps (the LTB stacks) have been specifically developed to support mastering essential skills and knowledge required in the field of practice placement. It organizes learning objectives into clear, achievable steps and provides digital resources to help to succeed. The key learning objectives of the practice placement were included.

The objectives will guide learning throughout clinical placements, ensuring that to develop both the theoretical understanding and practical skills needed for safe and effective patient care.

Addressing Challenges in the Clinical Setting

Clinical placements can be challenging, as they involve navigating the daily routines of a busy hospital, primary health care center and/or other healthcare institutions - while trying to absorb critical knowledge. Some of the common challenges include:

- **Learning to adapt to the clinical environment:** This includes working with different medical teams and managing patient contact.
- **Balancing knowledge and practical skills:** students will be exposed to various specialties requiring a wide range of competencies.
- **Varying mentor styles and motivation:** students may work with different mentors, each with their own teaching styles and expectations.

The 4D Mobile Apps (LTB stacks) help to overcome these challenges by providing a structured learning pathway that integrates theoretical knowledge with hands-on practice.

How the Learning Toolbox Creates Structure

The LTB is used to create a well-structured learning environment. Here's how it helps organize clinical practice, e.g.:

- **Scheduled Training and Seminars:** The 4D Mobile Apps (LTB stacks) provide access to scheduled seminars and practical skills sessions.
- **Portfolio and Reflection:** You'll maintain a portfolio where you can reflect on your learning objectives, complete case studies, and track your development over time. Reflection helps reinforce learning and allows you to identify areas for improvement.

Digital Learning and Resource Access

A key advantage of the Learning Toolbox is its ability to provide quick, mobile access to a variety of learning resources, such as:

- **Educational videos:** Demonstrations of techniques and procedures.
- **Guides and reading materials:** Links to essential reading and step-by-step instructions.
- **Assessment tools:** The 4D Mobile Apps (the LTB stacks) enable to assess progress and self-evaluate the achievement of learning goals through an added tool the Learning Goal Widget (LGW)

The 4D Mobile Apps (the LTB stacks) replace bulky printed handbooks with a mobile-friendly, digital solution that allows access to learning materials on the go, whether on a smartphone, tablet, or computer.

Accessing the 4D Mobile Apps (the LTB stacks)

Getting started with the LTB is simple with the access of the platform via QR (Quick Response) code or URL (Uniform Resource Locator), which will direct to the relevant LTB stack. Students were asked to create an account to save progress and personalize the learning experience. Once logged in, they will have access to all the tools and resources available within 4D Mobile App (the LTB stack). The LTB can be accessed via your mobile device, allowing you to track your progress, view learning materials, and complete exercises from anywhere.

Using the Learning Toolbox for Clinical Education

The 4D Mobile Apps (LTB stacks) are a go-to resource for managing clinical education. It provides Step-by-step guides with Instructions for completing clinical tasks, such as taking patient histories or performing procedures. Students can track their development with monitoring the learning progress and assess the achievement of learning goals through LGW in real time.

The LTB facilitates communication between the student and the mentors, enabling regular feedback on their performance. The system also allows users to upload notes, photos, and case study reports, creating a comprehensive record of the clinical experiences.

Interactive Learning and Exercises

To help to get familiar with the Learning Toolbox, several interactive tasks were available. Students and mentors were asked to locate key resources and learning goals within the 4D Mobile Apps (the LTB stacks).

These exercises will ensure that students and mentors are comfortable using the 4D Mobile Apps (the LTB stacks) and can maximize its benefits throughout the clinical placement.

Participating in the Pilot Study

As part of an ongoing effort to improve the 4D Mobile Apps (the LTB stacks), students and mentors were asked to take part in the pilot study that has been conducted to gather feedback from students and mentors. The input will help to refine the approach and enhance its effectiveness.

4. Identification of strengths, weaknesses, opportunities and threats of the diversity of the different practice placements and adoption of mobile technology

During a co-creation workshop in May 2024 at Tecnocampus partners aimed to work on the initial evaluation and good practices on introducing technology in practice placement, to develop the second outcome result, titled: "Toolkit: Successful Adoption of Mobile Technology in Practice-Based Learning." The main goal was to engage end-users in validating the application developed during the first pilot phase, using the findings to guide the next reiteration stage.

The workshop was designed to facilitate knowledge sharing among stakeholders, focusing on the strengths, weaknesses, opportunities, and threats (SWOT) related to the organizational and administrative aspects of practice placements. The project partners brought together various participants with different roles and responsibilities to explore how these elements intersect in practice-based learning.

The expected outcomes of the workshop included:

- **Knowledge base on organizational diversity:** A detailed SWOT analysis of the organizational and administrative diversity in practice placements.
- **Consensus on personalized mobile applications:** Agreement on developing tailored mobile applications for practice-based learning.
- **Sharing best practices:** Participants will exchange best practices to enhance digitalization in education.
- **Reflection on mobile app use:** Discussions will promote reflection on using mobile applications in education, particularly in Technology-Enhanced Learning (TEL) environments.

The workshop involved students, clinical tutors, practice placement managers and academic assessors, providing a dynamic and collaborative platform to integrate mobile technology effectively into practice placements. The results of the workshops and learning activity have been disclosed in the document “4D Learning activity: Experience and Evaluation” (Martínez-Gaitero, et al., 2024).

4.1. Knowledge base on organizational diversity (SWOT)

The SWOT analysis was conducted to understand the diversity in practice placement concerning organizational, administrative and educational execution.

The SWOT analysis highlights the strengths, weaknesses, opportunities, and threats across three healthcare institutions: UDE, MUL, and TCM:

- **Strengths** include well-structured placements, superior infrastructure, and career development support. UDE excels with its skills labs and student evaluations, while MUL offers international collaboration and access to modern medical simulation centers. TCM allows a balance between work and study, offering individual mentorship and diverse internships.
- **Weaknesses** focus on issues such as inconsistent placements, underqualified staff, and busy schedules. UDE struggles with teaching staff variability, while MUL faces challenges with overcrowded wards and unpaid students. TCM has logistical issues and limitations in evidence-based nursing practices.
- **Opportunities** revolve around digitalization, career development, and international exposure. UDE benefits from digitalization and mentorship, MUL emphasizes employment opportunities and international programs like ERASMUS+, and TCM provides career insights through forums and seminars.
- **Threats** include staff shortages, increasing student numbers, and external factors like the Ukrainian war. UDE faces risks from monetary incentive abuse, while MUL is concerned about the psychological impacts of the war and TCM grapples with high nurse-patient ratios.

Similarities across the institutions include strong practical exposure, potential employment opportunities, and issues with staffing. Differences highlight TCM's unique focus on work-life balance, UDE's emphasis on digitalization, and MUL's concern about psychological support. Each institution faces distinct challenges but shares common goals in improving healthcare education.

4.2. Consensus on personalized mobile applications

The needs assessment for TCM, MUL and UDE focuses on key areas: onboarding, reflection and feedback, and learning goals and evaluation, with both similarities and differences across the institutions.

- **Onboarding and Welcoming:** All institutions emphasize a smooth onboarding process. UDE focuses on easy access and logistical clarity, MUL seeks faster, more intuitive interfaces with language options, and TCM includes personal greetings from mentors and virtual maps of practice placements.
- **Reflection and Feedback:** UDE highlights searchable tools with reminders and clinical cases, while MUL emphasizes feedback viewing and document uploads. TCM prioritizes periodic feedback, mentor training, and chatbot support for immediate guidance.
- **Learning Goals and Evaluation:** UDE stresses clear goals, progress tracking, and open communication, MUL provides spaces for document uploads and feedback sharing, and TCM focuses on tailored evaluations, structured feedback tools, and incentives for clinical mentors.
- **Similarities** across all institutions include the importance of effective onboarding, clear learning goals, structured evaluation methods, and technological integration. However, there are differences in how each institution approaches onboarding, reflection, and feedback processes, as well as support systems and resources.

The takeaway emphasizes UDE's need for robust support and efficient evaluations, MUL's focus on document management and feedback, and TCM's priority on mentor training and comprehensive onboarding.

4.3. Sharing best practices

During the exchange of best practices students were mixed within the countries and divided into 3 groups, named "Phillips on the Rock", "Max and Storming" and "Iris Spritz". The mapping of best practices was referred to before the practice placement, during the practice placement, after practice placement as well as similarities and differences.

- **Before the practice placements,** all three groups emphasize thorough preparation." Phillips on the Rock" focuses on personalized course planning, mentor connections, and app-based preparation with schedules and documents. "Max and Storming" emphasizes early preparation of documents and increasing the number of teaching hospitals for more choices. "Iris Spritz" highlights the need for detailed timetables, departmental information, and providing competency requirements before the placement.
- **During the placements,** all groups agree on the importance of onboarding sessions and feedback. "Phillips on the Rock" includes ward tours and mid-placement evaluations, while "Max and Storming" emphasizes consistent training with tutors and practical seminars. "Iris Spritz" focuses on clear emergency protocols and ongoing feedback from tutors.
- **After placements,** evaluations and feedback play a key role. "Phillips on the Rock" includes end evaluations with feedback for both mentors and students, "Max and Storming" focus on individualized feedback and practical exams, and "Iris Spritz" emphasizes document collection and digital closure processes.
- **Similarities** include detailed preparation, structured onboarding, regular feedback, personalized evaluations, and centralized document management. Differences lie in each group's specific focus areas: "Phillips on the Rock" emphasizes digital planning and mentor engagement, "Max and Storming" stresses a variety of hospital placements and early documentation, and "Iris Spritz" highlights detailed upfront information and strong post-placement processes.

4.4. Reflection on mobile app use

Participants worked collaboratively to identify areas for improvement in the mobile applications of each practice site. This step aimed to generate actionable insights and recommendations for enhancing the functionality and usability of the apps.

The **Onboarding and Welcoming processes** at TCM, MUL and UDE focus on making the transition into clinical practice smooth and organized. MUL prioritizes a user-friendly interface, personalized homepages, tutor contact details, and class schedules that integrate with other courses. UDE promotes detailed FAQs covering clinic schedules, first-day preparation, emergency documentation, and the role of clinical tutors. TCM recommends virtual maps, updated schedules, mentor greetings, centralized document uploads, and detailed information about practice placements and hospital protocols.

Regarding **Reflection and Feedback**, MUL recommends individualized feedback during and after placements, emergency procedure documentation, notifications for new uploads, and customized document stacks for students. UDE includes features like an A-Z glossary, spaces for student identification photos, and clinical case information cards. TCM enables attendance registration directly via the app, internal messaging with link teachers, accident protocols, middle evaluations on strengths and weaknesses, and links to human resources.

For **Learning Goals and Evaluation**, MUL emphasizes complex evaluations with clear expectations for students, while UDE allows for individual feedback, tracks learning progress more visually, and includes a "Goodbye" document. TCM evaluates the Clinical Learning Environment (CLE), covering unit, clinical tutor, and placement assessments, with additional farewell information.

In summary, the institutions prioritize seamless onboarding, continuous reflection and feedback, and structured learning goals and evaluations, aiming to create a comprehensive and supportive educational environment for students in clinical placements.

A co-creation and co-design process can be used to share and capture insights into teaching and learning practices in complex practice placements settings. Including a wide range of stakeholders with different methods and tools helped everyone to express, explore and reflect on the insights, ideas and challenges that were identified resulting in mobile applications tailored to the users' needs.

5. Pilot-Study

5.1. Background

5.1.1. Background and rationale

Clinical education is a key component of healthcare training, providing students with the opportunity to apply theoretical knowledge in real-world settings under professional supervision. However, the nature of clinical placements presents several challenges for both students and educators. The fast-paced and dynamic clinical environment requires students to be adaptable and integrate their learning with minimal guidance, while mentors must provide structured support and feedback, often within time and resource constraints.

Some major challenges in clinical education include inconsistent mentorship and feedback, which can limit students' ability to make real-time improvements. Reflection and self-directed learning are also essential (Schön, 1983) but many students struggle to connect their clinical experiences with broader learning goals without proper guidance. Additionally, communication barriers, such as conflicting schedules and limited time for discussions, hinder effective interaction between students and mentors.

Another issue is the lack of structured learning tools. Traditional methods of managing clinical education, such as paper-based assessments, are often disorganized, making it difficult for students and mentors to track progress and provide timely feedback. The variability in clinical learning experiences across different placements also leads to inconsistencies, affecting both the quality of education and students' preparedness for future practice (Yardley et al., 2012).

The rapid advancement of technology has created new opportunities to address challenges in clinical education, particularly through technology-enhanced learning (TEL) tools. Mobile applications play a key role in improving communication, facilitating reflection, and offering structured ways to track and assess learning outcomes (Ellaway, 2008; George 2014).

Mobile devices, such as smartphones and tablets, are now common in healthcare settings, allowing students and educators to access educational resources, manage workflows, and maintain continuous communication in fast-paced environments George, 2013; Payne 2012).

One of the most significant contributions of TEL is its ability to enhance reflection and feedback. Digital tools can guide students through structured reflective exercises, helping them critically analyze their clinical experiences. These tools also enable mentors to provide timely feedback remotely, ensuring that students receive ongoing support even when face-to-face meetings are not feasible (Schön 1987). In this way, technology improves both the learning experience and the effectiveness of mentorship in clinical education.

Technology plays a crucial role in tracking and assessing learning goals in clinical education. Digital tools offer an organized platform for setting, monitoring, and reviewing learning objectives, giving both students and mentors a clear view of educational progress. This real-time tracking enhances accountability, helps students stay focused on their priorities, and allows mentors to provide feedback targeted at specific areas needing improvement. By streamlining this process, technology ensures that learning goals are consistently addressed and progress is easily measurable (Fessl et al. 2021).

The 4D Mobile Apps (LTB stacks) and the Learning Goal Widget (LGW) were developed to address challenges in clinical education and harness the potential of mobile learning. Its key functions include

- **facilitating the onboarding process** by providing students with essential materials and guidelines as they start their placements,
- **promoting reflective practice** through structured guidance for critical self-assessment, - and
- **tracking learning goals** by allowing students to set objectives, monitor progress, and receive feedback from mentors.

By focusing on these areas, the 4D Mobile Apps (LTB stacks) offer a more organized and supportive approach to clinical education, aiming to improve student engagement, enhance learning outcomes, and better prepare healthcare students for professional practice.

5.1.2. Rationale for the study

The introduction of 4D Mobile Apps (the LTB stacks) and LGW comes as healthcare education increasingly acknowledges the role of technology in enhancing student learning. While digital learning tools have shown benefits in classroom settings (Payne et al., 2012), their effectiveness in clinical environments is still underexplored. This pilot study aims to address that gap by evaluating the 4D Mobile Apps (the LTB stacks) usability, impact, and potential barriers in real-world clinical placements. The study collects data on user satisfaction, learning outcomes, and practical challenges to better understand how mobile learning tools like the LTB can support clinical education.

The results of this study could have significant implications for the future of healthcare education. If the LTB and LGW proves effective in improving communication, reflection, and management of learning goals, it could serve as a model for developing similar tools in other healthcare disciplines. As healthcare becomes more digitalized, integrating technology into clinical education is crucial for preparing future healthcare professionals effectively.

5.1.3. Objectives of the study

The primary goal of the study was to evaluate the usefulness, user experience, quality, effectiveness, and satisfaction related to a mobile application, while also gathering recommendations for its future development. The research focused on specific areas, including onboarding, reflective and feedback guidance, and the (self)assessment of learning goals, and was organized around several key questions.

The study assessed the usefulness of the 4D Mobile Apps (the LTB stacks) and the Learning Goal Widget (LGW) in delivering onboarding materials, providing reflection and feedback guidance, and presenting, tracking, and assessing learning goals. It also explored user experience in these areas and evaluated communication with clinical mentors, user participation, and the overall relevance of the tools.

Another focus was on the quality of learning and effectiveness, including whether the tools boosted students' confidence, helped with orientation and communication, and provided valuable reflective guidance during practice placements. The LGW was specifically assessed for its role in tracking learning goals, increasing knowledge of learning materials, and aiding student self-assessment.

The study further examined the tools' ability to support skill transfer and real-life tasks by determining whether they improved learning performance, helped students meet learning objectives, and simplified coordination with clinical mentors. Lastly, the study aimed to understand whether 4D Mobile Apps (the LTB stacks) and LGW were seen as relevant information sources and whether they would be recommended for long-term use.

5.1.4. Theoretical frameworks

This study is based on several theoretical frameworks that guide the design and evaluation of the 4D Mobile Apps (the LTB stacks) and Learning Goal Widget (LGW).

- **Kirkpatrick's Evaluation Model:** Originally developed in 1959, this model evaluates educational programs across four levels—reaction, learning, behavior, and results (Kirkpatrick, 1976). It was adapted for this study to assess user satisfaction, learning outcomes, behavior changes, and the overall impact of the tools. The model's adaptation to technology-enhanced learning (TEL) acknowledges the unique challenges of digital education tools (Ruiz, 2018) and was integral to evaluating the pilot study through questionnaires and interviews (John et al., 1988).
- **Affinity for Technology Interaction (ATI) Scale:** The ATI scale measures how comfortable and confident individuals feel when interacting with technology. It assesses users' readiness to adopt digital tools and their overall interaction experience. In this study, it was used in a pre-questionnaire to gauge participants' affinity for technology, helping to predict engagement and satisfaction with the mobile tools (Franke, 2019).
- **System Usability Scale (SUS):** SUS, developed by John Brooke in 1986, is a 10-item questionnaire designed to evaluate the usability of systems or products. It assesses how easy and efficient a system is to use, with scores ranging from 0 to 100. This tool was applied in the study to evaluate the usability of the LGW within the mobile application (Brooke, 1996).
- **User Experience Questionnaire (UEQ) Short Version:** This scale measures both the pragmatic (usability) and hedonic (emotional satisfaction) aspects of user experience. The short version consists of 8 items that assess how effectively users can achieve their goals (pragmatic quality) and how engaging and enjoyable the system is (hedonic quality) (Laugwitz, 2008). In this study, it was used to evaluate the onboarding experience and reflective practice provided by the 4D Mobile Apps (the LTB stacks).

These frameworks collectively provided a comprehensive approach to evaluating the effectiveness, usability, and user experience of the 4D Mobile Apps (the LTB stacks) and LGW in clinical education.

5.2. Methodology

5.2.1. Study design including participants and sampling

The pilot study employed a pre- and post-quantitative data-collection on the Learning Tool's (4D Mobile Apps (the LTB stacks) and LGW) impact. After an introduction of the project and the pilot-study students were asked to answer the pre-questionnaire, during the introductory events of the courses. They were shown a QR-Code to get access to the questionnaire on the platform Redcap (https://projectredcap.org) which was used for the pre- and post-questionnaire. After completing the course in their practice placements, the students were asked to complete the post-questionnaire on the same platform with a different QR-Code.

This design allowed the researchers to measure prior experience, user satisfaction, usability, user experience and effectiveness. The study involved a purposive sample of 200 healthcare students from the partner institutions. Students were required to be actively enrolled in clinical placements. Throughout their placements, participants used the 4D Mobile Apps (the LTB stacks) & LGW to manage learning goals, receive feedback, engage in reflective practices and (self)assessment at the practice placement. Consent of the participants for the study was obtained after the aim and purpose of the study was explained to the participants.

5.2.2. Data collection instruments

Pre-questionnaire

A pre-questionnaire was administered to participants before they started using 4D Mobile Apps (the LTB stacks). The pre-questionnaire collected demographic information and data on participants' technical affinity, prior experience with learning tools, and expectations regarding the use of the 4D Mobile Apps (the LTB stacks). Key areas included:

- **Demographics**: Age, gender and prior experience with LTB or mobile application in general.
- **Technical Affinity:** Measured using the Affinity for Technology Interaction (ATI) scale (Franke, 2019) which assesses an individual's comfort and confidence with technology. Higher ATI scores indicated a greater ease with adopting new technologies.
- **Expectations:** Questions focused on participants' expectations regarding the benefits of the 4D Mobile Apps (the LTB stacks), including how a mobile application could support learning during practice placements.

Available in: https://redcap.tecnocampus.cat/surveys/?s=KMT47M47K37N3MEP

Post-questionnaire

At the conclusion of the clinical placement, participants completed a post-questionnaire that evaluated their experiences with the 4D Mobile Apps (the LTB stacks) & LGW. This questionnaire was designed to assess demographics, learning & training outcomes and affective reactions what was used to measure effectiveness, efficiency, and user satisfaction with LGW.

Referring to the mentioned literature, the questions were classified to assess the following levels: REACTION, LEARNING & BEHAVIOR, and RESULTS, focusing on the areas of Onboarding, Communication & Documentation and Reflective Practice & Feedback within the 4D Mobile Apps (the LTB stacks), as well as the (self-)assessment and Learning Goals within the Learning Goal Widget (LGW) (see Table 1).

Available in: https://redcap.tecnocampus.cat/surveys/?s=XKNWJR34C8FDEYKL

Level	Measured by	Topics
REACTION	**Usefulness & Learning experience**	*Program objectives*
		Relevance
		Level of participation
		Affective reaction
LEARNING & BEHAVIOR	**Quality of learning & effectiveness**	*Onboarding material*
		Reflection guidance
		Providing, tracking and assessing of learning goals
	Tool capabilities to transfer skills & Level of supporting real-life tasks	*Self-assessment*
		Learning effect
RESULTS	**Final targeted outcome of the app**	*Long-term-usage*

Table 1: Level and Measurement topics of the post-questionnaire to evaluate the Learning toolbox and Learning goal widget according to the theoretical frameworks of Kirkpatrick, 1976 and the adaption for TEL of Ruiz, 2018.

5.2.3. Data Analysis

Quantitative data from the pre- and post-questionnaires were analyzed using descriptive statistics (e.g., mean values, standard deviations) to assess overall trends in user satisfaction, usability, and learning outcomes.

ATI Score

Data from the Affinity for Technology Interaction (ATI) scale, which uses a 5-point Likert-type responses from "strongly disagree" to "strongly agree," were scored and summed to generate a total ATI score, with higher scores reflecting a greater affinity for technology interaction (Franke, 2019). Descriptive statistics were applied to summarize the data, including mean scores to identify the central tendency and standard deviation and variance to assess score variability among participants. The reliability of the ATI scale was evaluated using Cronbach's Alpha, with values above 0.7 indicating good internal consistency in measuring the construct. Additionally, comparative analysis (t-test) examined differences in ATI scores across demographic groups, such as gender and age, to better understand how various populations interact with technology.

Short UEQ-Scale

The short version of the User Experience Questionnaire (UEQ-S) measures user experience through a structured analysis process (Laugwitz, 2008; Schrepp, Hinderks eta l 2017). It consists of 8 items divided into two dimensions: Pragmatic Quality (usefulness and task orientation) and Hedonic Quality (enjoyment and stimulation). Participants rate items on a Likert scale from -3 to +3, and mean scores for each dimension are calculated. Descriptive statistics, including mean scores and standard deviations, summarize the overall user experience. Reliability is assessed using Cronbach's Alpha, with values of 0.7 or higher considered acceptable. Confidence intervals measure the precision of mean estimates, with narrower intervals indicating greater reliability. Finally, results are interpreted to evaluate usability and enjoyment; high scores in both dimensions suggest a positive overall user experience.

SUS

To calculate the System Usability Scale (SUS) score, responses to odd-numbered items are adjusted by subtracting 1 from the user's answer, while even-numbered items are scored by subtracting the response from 5. After scoring all items, the adjusted scores are summed and multiplied by 2.5, resulting in a final score ranging from 0 to 100 (Brooke, 1996).

A SUS score of 80.3 or above indicates excellent usability, while scores between 68 and 80.3 suggest good usability with room for improvement. Scores below 68 reflect significant usability issues. The average SUS score is around 68, which marks the 50th percentile, meaning scores above this indicate better usability, and those below suggest a need for enhancements.

The SUS is popular for its quick administration and reliability, even with small samples, serving as a useful tool for assessing overall usability. However, it has limitations, as it does not explain why users find a system easy or difficult to use or address specific factors like accessibility. For a deeper understanding of usability challenges, further user research may be required.

To evaluate inter-rater reliability, Cohen's Kappa was used to determine the consistency with which two different instruments rate or categorize the same item (Cohen, 1960)

Additionally, we analyzed the grade distribution of the SUS-Score provided by participants across all sites, as well as the relationship between this score and factors such as prior use of LTB, the use of other learning tools, and the frequency of LGW usage.

5.2.4. Ethical consideration

Ethical approval for the study was granted by the institutional review boards of all participating institutions, and all participants provided informed consent. The study prioritized patient privacy, ensuring that any data entered into the LTB by students was anonymized and securely stored in compliance with data protection regulations.

5.3. Results of the pilot-study

5.3.1. Pre-questionnaire

5.3.1.1. Demographics and experience

A total of 193 students participated in the pre-questionnaire, with 20 from the School of Health Sciences TecnoCampus Mataró-Maresme (TCM), 29 from the Medical University of Lublin (MUL), and 144 from the Medical faculty of the University Duisburg-Essen (UDE). The sample consisted of a higher proportion of female students (67%) compared to males (33%). Specifically, TCM had 80% female respondents, MUL had 86% female and 14% male, and UDE's distribution was 61% female and 39% male.

The average age of participants was 24.1 years, with students from MUL being slightly younger.

Regarding the use of the Learning Toolbox (LTB) prior to the course, there were notable differences among the groups. At TCM, 80% of students indicated they used the LTB very rarely or not at all, while all participants from MUL reported they had never used it. In UDE, 37% had never or rarely used the LTB, 30% used it occasionally, and only 3% used it frequently. Overall, approximately two-thirds of the students were unfamiliar with the LTB.

Additionally, around half of the students across all institutions reported using other mobile learning tools occasionally to frequently, with very few indicating they never used them. This suggests varying degrees of familiarity with mobile learning tools among the different student groups.

5.3.1.2. Affinity for Technology Interaction

The Affinity for Technology Interaction (ATI) score (Franke, 2019) showed an overall mean score of M=3,76, with similar results across the different groups: MUL (M=3,67), TCM (M=3,75), and UDE (M=3,81). This indicates a moderate inclination toward technology use. The Cronbach's indicating good internal consistency.

5.3.1.3. Expectations

Welcome process

Students were asked open-ended questions about their expectations regarding the welcome process. We received 19 responses from TCM, 23 from MUL, and 87 from UDE, totaling 125 responses.

The responses were grouped into several categories across all three sites, including:

- Information/Organization
- Communication
- Documentation

- Learning Process
- Usability
- Technology Implementation
- Exam Preparation
- Various general comments related to structure, simplification, efficiency, etc.

The pre-questionnaire findings highlight students' expectations regarding the mobile application's role in their orientation process. Students desire the app to provide convenience by streamlining orientation and practical processes, reducing paperwork, and expediting documentation. They want features that facilitate connections with mentors, improve communication within clinical settings, and offer detailed information about placements, departments, and procedures.

Key needs include consolidating essential documents such as timetables and internship requirements, enhancing communication with clinical mentors and tutors, and supporting learning by providing guidance on materials and objectives. Usability is also a priority; students expect the app to be user-friendly, fast, and intuitive, with easy navigation and access to information.

Overall, students across various universities seek a centralized, easy-to-use app that delivers structured information about their practical placements, fosters mentor communication, and aids in managing their learning goals. There is a clear demand for better organizational support and digital tools to enhance the learning experience.

Feedback and reflective practice

The open-ended question regarding expectations for the feedback and reflective practice process resulted in 20 responses from TCM, 29 from MUL, and 144 from UDE, totaling 153 answers. The responses were categorized as following:

- Information/Organization
- Documentation
- Learning Process
- General Expectations (e.g., structure, fast access, etc.)

Participants' expectations for the mobile app regarding feedback and reflective practice reveal several key themes.

Many students expressed a desire for a user-friendly app that facilitates feedback evaluation, tracks learning progress, and enables continuous communication with clinical tutors. A significant number of respondents from TCM highlighted the need for a reflective space within the app, akin to a diary, to allow for personal reflection and ongoing evaluation.

Requests for improved communication tools were common, with participants wanting chat functions to connect with clinical mentors and tutors for addressing questions and concerns. Additionally, students from MUL and UDE emphasized the importance of clear learning goals, tracking achievements, and having structured overviews of completed and pending tasks.

Lastly, suggestions included enhancing the app's usability for easy navigation and quick access to relevant documents and learning materials. Overall, feedback focused on improving communication, usability, reflection, and alignment with learning goals across all participating sites.

Process of assessing learning goals

The open question regarding expectations for the process of assessing learning goals generated 10 responses from TCM, 22 from MUL, and 51 from UDE. The responses were categorized as follows:

- Learning goals
- Learning process

- Usability of technology
- Acceptance by staff
- (Self)Assessment/Reflection
- Complexity
- General expectations, such as usability and the introduction of the app

Students provided feedback on their expectations for the Learning Goal Widget (LGW) and its role in assessing learning goals, highlighting several key insights. They desire an intuitive and user-friendly application that clearly helps them understand and track their learning goals. Many students expect the app to streamline self-assessment processes, visualize their progress, and facilitate performance evaluation.

They also hope the app will guide them through their learning journey with organized study aids and materials vetted by instructors, making it easier to monitor their progress. A strong emphasis was placed on the importance of self-reflection features that allow students to track their development over time and receive feedback on their self-assessments.

Technical concerns were raised regarding offline accessibility, app speed, and the risk of data loss or crashes, underscoring the need for the app to function reliably. Additionally, students expect the app to encourage feedback from mentors and clinical tutors, though some expressed concerns about staff readiness to effectively utilize the tool.

In summary, students want the LGW app to simplify learning goal assessments, support self-reflection, ensure technical reliability, and promote mentor feedback.

Expected Difficulties

The open question regarding anticipated difficulties received 16 responses from TCM, 16 from MUL, and 119 from UDE. The main categories identified across all three sites were as follows:

- Implementation of Technology
- Usage and Usability
- Acceptance by Staff
- General Issues such as coverage, time constraints, and motivation

Students expressed several concerns regarding potential difficulties in using the mobile app. Prominent issues included problems with internet connectivity, mobile network coverage, and device storage, particularly at TCM and UDE. Additionally, there were fears that some staff members, especially veteran nurses, might resist using the app, a concern especially noted at TCM.

Students from MUL and UDE highlighted worries about the app's navigation complexity, including potential crashes, freezing, and a lack of clear instructions. At UDE, issues with content clarity, confusion over subfolders, and technical bugs that hindered usability, such as scrolling difficulties and smartphone compatibility problems, were reported.

Participants across all sites were concerned about being overwhelmed by the app's design and excessive navigation options. There were also concerns about the appropriateness of using cell phones in clinical settings. Overall, significant challenges identified included technical functionality, staff acceptance, and usability challenges, especially in navigating the app and ensuring its performance in clinical environments.

5.3.2. Post-questionnaire

5.3.2.1. Numbers, demographics & pre knowledge

A total of 86 students completed the post-questionnaire, including 8 from TCM, 19 from MUL, and 59 from UDE, resulting in an overall dropout rate of 44.5% across all institutions. The demographic analysis revealed that a larger proportion of respondents were female (69%) compared to male students (31%).

The average age of participants was 23.94 years, with similar age distributions across all sites, though students at MUL were slightly younger. The age distribution remained consistent with that observed in the pre-questionnaire.

In terms of the Learning Toolbox (LTB) usage, over half of the students (63%) indicated they had never or rarely used the LTB prior to the course. About one-third reported occasional use, while only a few used it frequently. Specifically, at TCM, 67% of students stated they had never or rarely used the LTB, with 13% using it occasionally and another 13% often. At MUL, 69% had not used the LTB, while 31% reported occasional or rare usage. In UDE, 60% had never or rarely used the LTB, while 38% used it occasionally, and 4% reported frequent use.

Additionally, 58% of students across all sites reported using other mobile learning tools occasionally, often, or frequently, while 42% had never, very rarely, or occasionally used them. At TCM, 63% of students reported frequent use of other mobile learning tools, with the remaining 37% falling into the never, very rarely, or occasionally categories, each accounting for 13%. At MUL, 42% of students used mobile learning tools frequently, while more than one-third (37%) used them sometimes or often, and 21% reported infrequent use. At UDE, 51% of students frequently used mobile learning tools, one-third (33%) used them occasionally, and 19% never or rarely used them.

5.3.2.2. Learning Toolbox (4D Mobile Apps & the LTB stacks)

Learning & training outcomes (4D Mobile Apps & the LTB stacks)

The REACTION level, evaluated through Usefulness and Learning Experience related to program objectives and relevance, indicated a somewhat positive trend in students' perceptions of the mobile app's effectiveness in outlining learning objectives (M = 3,67). Students from MUL were particularly inclined to agree with this assessment. There was also a slightly positive inclination among students regarding their ability to connect learning objectives with practical experiences (M = 3,5), along with a belief that the course content was well-structured (M = 3,66).

When it came to the alignment of course material with clinical practice, responses were moderately positive overall (M = 3,81). Students at TCM expressed a moderately positive view on the usefulness of assessing learning objectives for reflecting on their learning, while MUL students had slightly positive feelings and UDE students remained neutral.

In terms of linking their learning process with feedback from clinical tutors, students from MUL and TCM reported a slightly positive response, whereas those at UDE tended to disagree. Regarding the app's relevance for future clinical practice, students at MUL showed a slightly positive trend (M = 3,79), while those at TCM (M = 2,63) and UDE (M = 2,75) exhibited a slight tendency to disagree.

In terms of participation levels, over one-third of students used the mobile application daily, while half engaged with it once or a few times per week. Only 8% reported never accessing the app. At TCM, a significant majority (75%) accessed the app weekly, with 13% using it a few times during the week and another 13% several times a day. At MUL, 47% of students used the app multiple times each day, 21% once daily, 15% weekly, and 16% a few times a week. At UDE, nearly a third (27%)

accessed the app a few times weekly, 10% used it once or several times daily, and 25% accessed it weekly, while 12% reported never using it.

At the LEARNING & BEHAVIOR level, assessed through the Quality of Learning & Effectiveness related to onboarding (see table 1), students generally agreed that the welcome materials were easily accessible within the mobile application (M = 3,75). Students from TCM displayed particularly strong support for this view. When asked if the reception information addressed their questions, the majority expressed a positive sentiment, indicating agreement.

Regarding the impact of the reception materials on their confidence during clinical practice, students overall showed a moderate level of agreement (M = 3,94), with those from MUL leaning slightly more towards agreement than their peers. In the context of reflection guidance, students generally agreed that the reflective practice and feedback guide aided their reflection on clinical tasks when using the app (M = 3,94). However, MUL students were more inclined to support this statement, while UDE students exhibited a lesser degree of agreement.

When asked if the reflective practice guide assisted in bridging theory and practice, students expressed a slightly positive viewpoint overall (M = 3,22), with MUL students learning positively and UDE students remaining neutral. Concerning whether the reflective practice guide and feedback increased their confidence during placements, the general sentiment was neutral (M = 3); however, MUL students tended to agree more, while UDE students had a slightly negative perspective.

The effectiveness of the tool in transferring skills and supporting real-life tasks at the LEARNING & BEHAVIOR level was assessed through self-assessment and perceived learning effects. Students generally had a slightly positive view on whether the mobile app enhanced their learning during internships (M = 3,24), with those from MUL showing stronger agreement.

Additionally, students felt positively about the app's role in helping them achieve their learning objectives in practice and enhancing their overall educational experience. Students from TCM and MUL were more likely to agree with these sentiments, while those from UDE had a more neutral response.

When evaluating whether the mobile app enabled students to better utilize learning opportunities and activities, responses were neutral overall (M = 3,17); however, MUL students had a slightly positive opinion, and TCM students expressed a more favorable view. This statement was deemed inapplicable by students at UDE.

In terms of facilitating communication with clinical mentors, TCM students reported a positive impression, while MUL students were neutral, and UDE students disagreed with the assertion.

The RESULTS level, which evaluated final target outcomes related to long-term usage, indicated that students generally agreed with the idea of recommending the mobile app for other courses and internships (M = 3,54). Students from TCM expressed strong approval, while those from MUL showed moderate agreement and UDE students had a somewhat positive view.

Overall, students tended to have a slightly favorable opinion about recommending the mobile app to peers or using it as a resource for relevant information (M = 3,34). TCM students were notably supportive of these statements, MUL students exhibited a moderately positive inclination, and UDE students displayed a more neutral stance

Affective Reactions (UEQ-S)

The affective reaction topic for 4D Mobile Apps (the LTB stacks) was evaluated using the short version of the UEQ-S (Laugwitz, B., Schrepp, M. & Held, T., 2008), which assesses user experience based on

pragmatic and hedonic qualities. The results indicated a positive outcome for 1 out of 4 items related to pragmatic quality and 2 out of 4 items pertaining to hedonic quality.

Overall, the evaluation yielded a neutral score for pragmatic quality, recorded at 0.644 on the short UEQ scale, while hedonic quality received a more favorable score of 0.852. However, the confidence intervals (p = 0.05) for the individual items and scales revealed low consistency in the evaluations, suggesting some variability in the responses. Nevertheless, the alpha coefficients for internal consistency were adequate, with scores of 0.88 for pragmatic quality and 0.86 for hedonic quality, indicating reliable measurements in both areas.

5.3.2.3. Learning Goal Widget (LGW)

The questionnaire also assessed the Learning Goal Widget (LGW) using a modified version of Kirkpatrick's Model tailored for technology-enhanced learning (Ruiz, 2018). This evaluation covered several aspects, such as user reaction to usability through the validated System Usability Score (SUS), as well as its usefulness and learning experience, quality of learning and effectiveness, and specific features related to transferring skills and supporting real-life tasks.

This methodology enabled a thorough evaluation of how effectively the LGW facilitated the learning process, focusing on both user satisfaction and its role in helping students meet their learning objectives in practical settings.

Learning & Training outcomes (LGW)

The REACTION level for the Learning Goal Widget (LGW), assessed through Usefulness and Learning Experience, was analyzed in relation to program objectives. Overall, students had a neutral view on the usefulness of tracking and evaluating learning goals (M = 3), with TCM students leaning towards a generally positive assessment, MUL students showing a slightly positive stance, and UDE students expressing a slightly negative perspective.

When it came to the complexity of monitoring and evaluating learning objectives in the evaluation section, UDE students exhibited a moderate agreement with the notion that the process was complicated (M = 3,63). In contrast, MUL students offered a slightly negative assessment (M = 2,58), while TCM students generally viewed it negatively (M = 2,29).

The Level of Participation for the Learning Goal Widget (LGW) indicated that approximately half of the students (52%) utilized the self-assessment feature to monitor their learning progress in relation to the learning objectives on a weekly basis. Around one-third (28%) reported never using this feature, while a smaller proportion engaged with it more frequently: 9% used it a few times each week, 6% accessed it once daily, and 1% utilized it several times a day.

At TCM, every student reported using the self-assessment feature on a weekly basis (100%). Similarly, 47% of students at both MUL and UDE utilized it once a week. However, a notable portion of UDE students (39%) indicated that they never used this feature.

At MUL, some students accessed it more frequently, with 16% using it a few times each week, 21% once daily, and 5% several times a day. Conversely, at UDE, only 8% engaged with the feature a few times weekly, and 2% used it several times a day.

Regarding Affective Reaction, students at UDE expressed difficulty in monitoring and evaluating learning goals in the relevant section, showing a moderate level of agreement with this concern. In contrast, students at MUL tended to have a slightly negative view, while TCM students generally held a negative opinion on this matter.

Affective Reactions – LGW (SUS)

The System Usability Scale (SUS) (Brooke, 1996), which evaluates perceived usability based on effectiveness, efficiency, and satisfaction (SUS), yielded an overall score of 60.5 out of 100 from 81 students. This score is classified as Grade D on the SUS interpretation scale, indicating a poor average rating for the usability of the Learning Goal Widget (LGW) at first glance.

To evaluate inter-rater reliability, Cohen's Kappa was used to determine the consistency with which two different instruments rate or categorize the same item (Coehen,1960). The results showed almost perfect agreement across all sites (0.89).

The distribution of SUS scores among participants from all sites, along with its correlation to factors such as prior usage of the Learning Toolbox (LTB), the use of other learning tools, and the frequency of Learning Goal Widget (LGW) usage, showed no significant differences. While TCM was the most critical site, it still came close to achieving a satisfactory rating.

When analyzing grade distribution by center in relation to gender, no significant differences emerged across the sites. Students who reported using the 4D Mobile Apps (the LTB stacks) occasionally during their practical placements received higher ratings compared to those who used it frequently. Additionally, there was no substantial difference in SUS scores between students who utilized other learning tools and those who did not. However, a clear correlation was found between the frequency of LGW usage and the evaluation of the system. Students who frequently used the LGW to self-assess their learning progress gave high SUS scores, and 80% of those who used the LGW occasionally rated it as good to excellent.

The SUS can be divided into two components: Learnability and Usability. The mean and standard deviation for these components were calculated separately across all sites, along with their relationships to prior LTB usage, the use of other learning tools, and LGW usage frequency. Overall, SUS scores for Learnability (71,5) and Usability (44,6) across all sites were rated as good, particularly at UDE. In contrast, TCM and MUL provided more critical ratings, classifying Learnability as acceptable and Usability as the lowest rating at all locations. Generally, students found the application easier to learn than to use.

Students who had frequently used the LGW prior to the study rated Learnability as excellent (100), though the number of frequent users was limited. These findings support the earlier observation that Learnability was rated more favorably than Usability within the SUS scores, regardless of usage frequency.

Learnability received ratings ranging from good to excellent, regardless of whether students used other mobile learning tools. Furthermore, students who engaged in self-assessing their learning progress against objectives rated the SUS scores higher, achieving ratings of OK to good compared to those who used the tool less often or not at all. Regular users of the tool also rated Learnability more favorably.

In the LEARNING & BEHAVIOR level, evaluated through the Quality of Learning & Effectiveness in the context of Providing, Tracking, and Assessing Learning Goals, students conveyed opinions ranging from slightly positive to neutral about the impact of self-assessment on their understanding of learning topics and goals (M = 3,12). Students from TCM demonstrated a generally positive outlook, while those from MUL showed a slightly positive perspective, and UDE students expressed a somewhat negative view.

When it came to recognizing their progress toward learning goals through self-assessment, the overall feedback was somewhat negative (M = 2,86). UDE students tended to have a generally unfavorable opinion, whereas TCM and MUL students exhibited a moderately positive inclination.

The assertion that using the LGW for self-assessment improved students' ability to evaluate their progress was also rated negatively (M = 2,3). UDE students largely disagreed with this statement, while TCM students leaned toward agreement, and MUL students maintained a somewhat negative stance.

In the context of Tool Capabilities to Transfer Skills and Support Real-Life Tasks, which encompasses the learning effect and self-assessment, the evaluations indicated differing perspectives. When asked whether the assessment and learning goals section provided adequate support with learning materials for effectively mastering their objectives in practice, TCM students exhibited a moderate level of agreement, MUL students expressed a slightly positive view, while UDE students had a somewhat negative outlook. Overall, students tended to express a slightly negative opinion (overall M = 3,45).

Regarding the ease of communication with clinical tutors facilitated by the assessment and learning objectives section, the general feedback was largely negative (M = 2,37). TCM students had a slightly positive perspective, MUL students remained neutral, and UDE students leaned toward a negative view, showing a tendency to disagree.

In evaluating whether the assessment and learning objectives section helped students capitalize on learning opportunities, TCM students displayed a moderate tendency toward agreement, MUL students expressed a slightly positive opinion, and UDE students had a somewhat negative view. The overall assessment concluded with a slightly negative opinion (M = 2,7).

Meeting Expectations

Students were asked to comment on whether the mobile app met their expectations regarding orientation within their clinical practice, achieving their learning goals, and reflecting on learning during hands-on activities.

- **Orientation in Clinical Practice.** Regarding the expectations for orientation within their clinical practice, and whether the app meet those expectations or not, the results included responses from 2 students at TCM, 12 from MUL, and 35 from UDE, for a total of 49 responses.

The responses fell into similar categories across all three sites. However, the category "communication" was only mentioned by students from TCM, while the category "use on ward" was exclusively mentioned by students from UDE. The categories mentioned included:

- Met expectations
- Learning content
- Communication
- Implementation of technology
- Positive feedback
- Constructive feedback
- Use on ward
- Room for improvement

Participants had varied expectations about the mobile app, with some having none while others found it effective for accessing learning materials, schedules, and communicating with clinical mentors. However, difficulties were reported, particularly with the so-called “chat function”. Many appreciated the app’s ability to consolidate resources, aiding in knowledge organization, but some found it challenging to navigate and suggested improvements for a more intuitive experience.

Technical issues were also noted, such as chat functions freezing and challenges in locating specific documents. Users recommended simplifying the app's structure, enhancing navigation, and improving usability. Suggestions for additional features included implementing a checklist and better integration with platforms like Moodle.

Overall, users advocated for a reduction in the number of clicks required to access crucial information and a more streamlined navigation process. They proposed practical enhancements like instructional videos, improved search functions, and a more unified platform to reduce confusion among various learning tools.

In summary, the presentation reveals that while the app was generally helpful in organizing and accessing information for clinical practice placements, there are notable areas for improvement, particularly in usability and simplifying its structure.

- **Achieving Learning Goals.** Regarding the expectations for the assessment of learning goals and whether the application met those expectations, or if not, why it didn't, the results included 2 responses from TCM, 9 responses from MUL, and 20 responses from UDE, totaling 31 responses.

Some responses fell into similar categories, although a few categories, such as feedback and implementation/features, were only mentioned by students at UDE, while the category learning goals was exclusively mentioned by students from MUL. Students at TCM only referenced the category assessment. The categories mentioned included:

- Assessment
- Meeting expectations
- Learning objectives
- Learning content
- Feedback
- Implementation/features

Students from various universities had mixed feelings about the Learning Goal Widget (LGW). While some felt it effectively helped them track learning goals, access materials, and monitor their progress, others, particularly from the University of Duisburg-Essen (UDE), found the assessment process cumbersome and misaligned with their expectations.

Usability was a significant concern for UDE students, who described the reflection and evaluation process as overly complex, with unclear guidelines for using the rating system. Some even preferred paper-based assessments due to the challenges posed by the online tool.

A common issue across universities was the lack of meaningful engagement from mentors in the evaluation process. UDE students reported that evaluations felt arbitrary and lacked personal interaction, while mentors at the Medical University of Lublin (MUL) were minimally involved in assessing practical skills. Students also struggled to receive timely feedback from mentors and questioned the practicality of online assessments.

Despite the tools being recognized for its helpful learning materials, many students, especially at UDE, suggested that it would benefit from clearer organization, improved search functionality, and a better overview of content. Navigation through the app's multiple layers often hindered efficient access to information.

Students proposed several improvements, including a better structure and control panels, a more intuitive interface, a feature to mark completed chapters, and the ability to download edited reflections or learning questions. They also noted technical issues with PDFs and formatting inconsistencies.

While some students valued the learning tools and structured goals provided by the app, others felt that its complexity detracted from its overall effectiveness in supporting their learning and practical experiences.

In summary, while the LGW was seen as a valuable resource for tracking progress and learning, there were significant concerns about its usability, mentor involvement, and the assessment process. The

feedback suggests that improvements in structure, user experience, and clearer mentor-student interactions could enhance its overall effectiveness.

- **Reflection of learning.** Regarding expectations for the mobile app in relation to feedback and reflective practice, and whether the app meet those expectations or, if not, why it didn't, the results include 3 responses from TCM and 10 responses from MUL, totaling 13 responses. Due to the nature of the practice placements and reflective work on learning objectives at UDE, this question was not applicable to UDE students.

The responses indicated varying levels of satisfaction and whether expectations were met:

- Meeting expectations
- Learning content
- Clinical professionals
- Communication
- Critique

At the Tecnocampus (TCM), some participants highlighted the convenience of having all study materials accessible in one location, which facilitated their class preparation. However, others pointed out that clinical professionals' unfamiliarity with the app led to a lack of interest in providing feedback.

At the Medical University of Lublin (MUL), responses were mixed. While some users appreciated the app's functionality, such as tracking learning progress and consolidating materials, others criticized its transparency and felt it did not align with real-world practice settings.

Overall, participants acknowledged the app's usefulness for accessing resources and monitoring progress but raised concerns about transparency, communication, and the engagement of clinical professionals with the tool.

- **Free comments on LGW.** Students were asked to leave any comments related to the assessment and learning goals section. The results included one response from TCM, 8 from MUL, and 18 from UDE. The categories mentioned were as follows:

- Assessment
- Introducing LTB/LGW
- Implementation of technology
- Learning content
- General remarks

- **Evaluation Methods.** Some students and mentors found the star rating system (0-5 stars) confusing, preferring numerical grades (like 8 or 9) instead. Concerns were raised about inconsistencies in evaluations across different courses, with UDE students noting a lack of personalized interaction with mentors, leading to arbitrary assessments.

- **User Experience & Design.** Students from the Medical University of Lublin (MUL) reported that the LGW-app was not user-friendly and required time to learn its layout and functions, although it became helpful for achieving learning goals. UDE students described the LGW-app as clunky and not optimized for mobile use, calling for clearer instructions for both students and mentors.

- **System Integration Issues.** Across all institutions, students indicated that the LGW-app sometimes felt disconnected from clinical reality. For example, at UDE, mentors were often too busy to provide meaningful feedback, which hindered engagement. There were also complaints about having to complete both paper-based and app evaluations, causing confusion.

- **General Feedback.** Students at MUL and UDE expressed a desire for a more visually appealing app with improved readability and streamlined functions. They suggested enhancements for

document searching and notifications. Despite the criticisms, some acknowledged the app's potential in connecting theoretical knowledge with practical experience, although its success relies heavily on active mentor-student interaction, which was often lacking.

- **Technical and Implementation Challenges.** Students noted technical issues, such as the need for better text-saving features and proposed digital submissions for practical work. Many agreed that the tools could be more effective if better integrated into clinical teaching workflows, particularly for seminar tasks that remain paper-based.

Overall, the feedback highlighted that while the 4D Mobile Apps & the LTB stacks and LGW tools show promise, improvements are needed in usability, evaluation consistency, and mentor engagement.

5.3.2.4. Comprehensive Summary of results & Limitations

The post-questionnaire aimed to assess student satisfaction, usability, effectiveness, and experience with the mobile learning application, focusing on two tools: the 4D Mobile Apps (the LTB stacks) and the Learning Goal Widget (LGW). It utilized established usability metrics such as the Affective Reactions score (UEQ-S) and the System Usability Scale (SUS), and followed Kirkpatrick's Model to evaluate learning outcomes across four levels: Reaction, Learning, Behavior, and Results. A total of 86 students participated—8 from TCM, 19 from MUL, and 59 from UDE—with a dropout rate of 44.5%. The demographic data revealed that 69% of respondents were female, 31% male, with an average age of 23.94 years.

Key Findings by Kirkpatrick's Levels:

- **Reaction (Usefulness & Learning Experience)**

Program Objectives: Students generally felt the 4D Mobile Apps (the LTB stacks) effectively provided an overview of learning objectives, with MUL students rating this most positively (M = 3,84) and UDE students being more neutral (M = 3,66). All students agreed the app moderately helped link learning objectives to practice (M = 3,5), and they felt the subject material was organized (M = 3,66).

Complement to Clinical Practice: The course content was viewed as a valuable complement to clinical practice (M = 3,81), with TCM and MUL students expressing more agreement than UDE students. However, opinions varied regarding the app's usefulness for reflecting on learning, with TCM students being positive (M = 3,88) while UDE students were less enthusiastic (M = 2,71).

Level of Participation: About 41% of students accessed the app daily or multiple times a day, while nearly half used it weekly. Only 8% reported never using it. MUL had the highest participation rates, with 47% accessing the app several times a day, in contrast to UDE's more sporadic usage.

Affective Reaction (UEQ-S): The hedonic quality of the 4D Mobile Apps (the LTB stacks) was positively evaluated (M = 0,852), whereas the pragmatic quality received a more neutral score (M = 0,644), indicating that while students found the app enjoyable, its practical usefulness was seen as moderate.

- **Learning & Behavior (Quality of Learning & Effectiveness)**

Onboarding Material: Students generally agreed that onboarding materials in 4D Mobile Apps (the LTB stacks) were accessible and adequately addressed their initial questions (M = 3,94), with TCM students rating it the highest (M = 4,13) and UDE students being more neutral (M = 3,69). The

onboarding materials boosted confidence during clinical practice, particularly for MUL students (M = 3,89).

Reflection Guidance: Students viewed reflective practice and feedback guides in 4D Mobile Apps (the LTB stacks) as moderately helpful in relating tasks to practice (M = 3,4). MUL students reacted most positively (M = 3,95), while UDE students were less enthusiastic (M = 3,19) and felt the guides undermined their confidence (M = 2,67).

Self-Assessment & Learning Goals: The LGW was perceived to enhance learning during internships, with MUL students in strongest agreement (M=4.05), whereas UDE students were more neutral (M = 3,24). The LGW-app was seen as somewhat helpful in achieving learning goals (M = 3,31), but UDE students rated communication with clinical mentors poorly (M = 2,16), in contrast to the positive rating from TCM students (M = 4,25).

❖ **Results (Long-Term Usage & Recommendations)**

Recommendation: Students generally had a positive view of recommending LTB for other courses (M = 3,54), with TCM students being the most favorable (M = 4,63) while UDE students were less likely to recommend it (M = 3,29). Students also expressed a willingness to recommend the app to peers (M = 3,34), though TCM students rated this higher (M = 4,5).

Usage of the App as a Learning Tool: Over half of the students reported using the 4D Mobile Apps (the LTB stacks) for relevant information (M = 3,37), but responses varied significantly by institution. TCM students rated this highly (M = 4,38), while UDE students were more neutral (M = 3,11).

❖ **Learning Goal Widget (LGW)**

The LGW was evaluated through the System Usability Scale (SUS) and Kirkpatrick's Model for technology-enhanced learning.

SUS Score: The LGW received a low average score of 59.8 (Grade D), indicating usability issues. TCM students rated it slightly higher (60.31), while MUL's score was lower (55.79), reflecting overall dissatisfaction with its usability. Although students who frequently used LGW to self-assess their learning progress against learning objectives awarded excellent SUS-scores.

Learning Experience: Monitoring and evaluating learning goals with the LGW received neutral to slightly negative ratings. TCM students rated it positively (M = 3,75), while UDE students had more negative feedback (M = 2,56). UDE students found the evaluation process complicated (M = 3,63), suggesting difficulties in tracking learning goals.

Self-Assessment & Tracking: About half of the students used the self-assessment feature weekly, but one-third never engaged with it. UDE students were the least engaged, with 39% not using the feature, while MUL students reported higher usage, with 21% using it daily.

Learning Effectiveness: The self-assessment section of the LGW was rated poorly for improving students' ability to gauge their progress (M = 2,3). UDE students disagreed with this (M = 1,67), while TCM students were more positive (M = 3,5). The LGW's effectiveness in supporting learning objectives received a slightly better rating (M = 3,45), but UDE students remained negative (M = 3,18).

❖ **Limitations**

The limited number of respondents from TCM and MUL poses a challenge for generalizing the findings. Additionally, variations in practice placements—such as differences in content, organization, student and mentor ratios, interaction with university instructors, course duration, and learning goals—exist across all sites. Furthermore, the distinct designs of the mobile app at each location also represent a limitation because variations in design can influence how users interact with the app,

affecting both user experience and engagement levels. Differences in layout, navigation, functionality, and accessibility may result in inconsistent learning or practice outcomes across locations. For example, if one design is more intuitive or visually appealing, users there may engage more frequently or effectively with the app's content, leading to disparities that make it difficult to compare results or generalise findings across all sites. While completing the post-questionnaire and providing free-text comments, students may have had difficulty distinguishing between the 4D Mobile Apps (the LTB stacks), the LTB itself, and LGW. This affects the reliability of interpreting the results.

5.4. Short summary of the pre-questionnaire

The pre-questionnaire involved 193 students from three institutions: TCM, MUL, and UDE, with a higher proportion of female respondents (67%). The average age was 24.1 years, with notable differences in prior use of the Learning Toolbox (LTB). Many students, particularly at TCM and MUL, were unfamiliar with the LTB, while a significant portion of students reported using other mobile learning tools.

The Affinity for Technology Interaction (ATI) score averaged M=3.76, indicating a moderate inclination towards technology use across groups.

Students expressed various expectations for the mobile app in the orientation process, emphasizing the need for streamlined communication, organization of essential documents, and user-friendly navigation. They wanted the app to enhance mentor connections and provide structured information about placements and learning objectives.

In feedback and reflective practice, students desired an app that supports continuous communication with tutors, tracks learning progress, and offers a reflective space for personal evaluation. There was a strong demand for improved communication tools and structured overviews of tasks.

Regarding the assessment of learning objectives, students wanted a user-friendly interface to track progress, facilitate self-assessment, and receive feedback. They also highlighted the importance of technical reliability and offline accessibility, alongside concerns about staff readiness to use the app.

Finally, anticipated difficulties included potential issues with technology implementation, usability challenges, and staff acceptance, particularly among veteran nurses. Concerns about navigation complexity, technical bugs, and appropriateness of phone use in clinical settings were also prominent, indicating a need for robust support and clear instructions.

5.5. Short summary of the post-questionnaire

The post-questionnaire evaluated student satisfaction, usability, effectiveness, and overall experience with the mobile learning application, focusing on the 4D Mobile Apps (the LTB stacks) and the Learning Goal Widget (LGW). It used established metrics like the Affective Reactions score (UEQ-S) and the System Usability Scale (SUS), following Kirkpatrick's Model to assess learning outcomes across four levels: Reaction, Learning, Behavior, and Results. A total of 86 students participated—8 from TCM, 19 from MUL, and 59 from UDE—with a dropout rate of 44.5%. The demographic data indicated that 69% of respondents were female, with an average age of 23.94 years.

Overall, students felt the apps effectively presented learning goals, with the highest ratings from MUL. Many found the 4D Mobile Apps (the LTB stacks) useful in linking learning goals to practice, although opinions varied, with TCM students rating it positively for reflective learning while UDE

students were less enthusiastic. About 41% of students accessed the app daily or multiple times, with higher participation rates from MUL. While students enjoyed the app's hedonic qualities, its practical usefulness received a more moderate score.

In terms of learning quality and effectiveness, onboarding materials were generally seen as accessible and helpful, boosting confidence during clinical practice. Reflection guides were moderately helpful, but UDE students felt they undermined their confidence. The 4D Mobile Apps (the LTB stacks) were perceived to enhance learning during internships, particularly for MUL students, while UDE students reported poor communication with mentors through the tools.

Regarding long-term usage, students generally recommended LTB for other courses, with TCM students being the most favorable. More than half reported using the app for relevant information, though responses varied significantly by institution.

The LGW received a low average SUS score of 59.8, indicating usability issues. While TCM students rated it slightly better, overall dissatisfaction was evident. The learning experience with the LGW was rated neutrally to negatively, particularly by UDE students, who found the evaluation process complicated. Although about half used the self-assessment feature weekly, many did not engage with it at all. Students who regularly utilized the LGW for self-assessing their learning progress gave it high SUS scores. Overall, the LGW struggled to improve students' self-assessment capabilities and effectively support learning objectives.

6. Project Results from Work Package 4

The project results from WP4 called “Digitalisation of practice placements. Evaluation and good practices” of the 4D project (Determinants, Design, Digitalization, Dissemination) demonstrate substantial progress in integrating mobile technology within clinical education settings, with a focus on creating a supportive and effective learning environment for healthcare students. Through a structured and collaborative approach, the project achieved multiple objectives, primarily focusing on the feasibility and impact of digital tools designed to support practice-based learning.

The project’s central outcome was the application and testing of mobile learning tools tailored specifically for clinical education in practice placement. Two primary tools (apps) were designed and implemented across three European Higher Education institutions (HEIs): the 4D Mobile Apps (the LTB stacks) and the Learning Goal Widget (LGW). The 4D Mobile Apps (the LTB stacks) enabled students to access onboarding materials, document their progress and engage in reflective practices during their placements. The Learning Goal Widget provided a platform for students to track their progress against specific learning goals, receive structured feedback, perform self-assessments and receive assessments in real time. Together, these tools were customized for each participating institution to meet the unique requirements of their practice placements and foster an enriched learning experience that blends practical and theoretical knowledge.

The project also conducted a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis across the three participating institutions, which included UDE, MUL, and TCM, providing essential insights into the organizational and educational landscape of each site. Key strengths identified included structured placements, advanced infrastructure, and support for career development, which collectively create an effective foundation for practice-based learning. However, challenges emerged, such as inconsistent placement schedules and limitations in teaching resources, which needed careful attention to ensure consistent and high-quality learning experiences. Opportunities highlighted the potential of digitalization to enhance learning outcomes, while threats, such as staff shortages and external stressors like the Ukrainian war, emphasized the need for strategic planning to maintain a stable learning environment. This analysis facilitated a deeper understanding of each institution's specific needs, which informed the co-design and personalization of mobile learning applications.

In support of these digital tools, the project developed comprehensive training materials and feedback resources for both students and mentors. Materials such as the 4D Feedback Mini Guide and the Reflective Practice Mini Guide provided strategies for mentors to deliver effective feedback and for students to engage in reflective practices, both of which are essential for developing critical competencies in healthcare. The guides were designed to help students build their clinical knowledge and skills while also supporting their professional growth through structured reflection and feedback. Additionally, these materials were reinforced through multiple training workshops to ensure students and mentors were equipped to use the digital tools effectively, aligning their digital experiences with the requirements of practice-based learning.

Another key outcome of the project was the establishment of collaborative workshops where students, educators, and institutional representatives exchanged best practices and provided feedback on the digital tools being piloted. Through these discussions, participants identified ways to optimize the implementation and functionality of mobile applications, with a particular emphasis on how digital tools can better support clinical placements. This collaboration helped participants refine approaches to digital learning, emphasizing the value of a shared knowledge base among institutions and fostering a cross-institutional dialogue on the best practices for integrating mobile technology in healthcare education.

Additionally, the project generated customized guidelines for the effective implementation of digital learning tools. Recommendations were organized to support the different stages of practice

placements, including onboarding, reflection, feedback, goal-setting, and assessment. The integration of mobile technology was carefully designed to be sustainable and responsive to the needs of both students and mentors, thus supporting the long-term adoption of these digital tools within healthcare settings.

Related to the key factors detected in PR1, the results from the pilot study of the 4D Mobile Apps (the LTB stacks) and Learning Goal Widget (LGW) for clinical education highlight the impact of mobile technology on enhancing the learning experience in healthcare practice settings. Here is a detailed summary of the primary findings:

- **Improvement in Onboarding and Orientation:** The 4D Mobile Apps (the LTB stacks) proved useful for onboarding, helping students access essential materials, timetables, and contact information needed for clinical placements. The structured layout aimed to streamline the orientation process and reduce the challenges of adjusting to new clinical environments.
- **Enhancement of Reflective Practice:** Both the 4D Mobile Apps (the LTB stacks) and LGW provided structured guidance for reflection, helping students critically evaluate their clinical experiences. The reflective guidance feature facilitated ongoing self-assessment, allowing students to track their development and improve based on feedback. However, responses varied by institution, with some students finding this process complex and, at times, diminishing confidence, especially in UDE.
- **Challenges with Communication and Usability:** Communication with mentors via the app was seen as insufficient, particularly among UDE students who reported difficulties in connecting with clinical mentors through the tools. The usability of the 4D Mobile Apps (the LTB stacks) and LGW received mixed reviews, suggesting room for improvement. Students cited issues such as navigation complexity, slow performance, and difficulty accessing specific features.
- **Support for Self-Assessment and Learning Goals:** The LGW enabled students to self-assess their progress against set learning goals, though it was inconsistently used across institutions. The tool's effectiveness in reinforcing learning goals received neutral to negative feedback, especially regarding the complexity of tracking and assessing learning progress.
- **Mixed Feedback on Long-Term Utility:** Students generally recommended LTB for future courses, although the response from UDE was more reserved. Students noted the app's potential as a centralized resource but expressed a need for better alignment with real-world clinical tasks and clearer mentor engagement in the evaluation process.
- **Technical issues and User Engagement:** Only a few technical issues were mentioned including device storage limitations. Additionally, staff acceptance varied, with some students feeling that mentors were reluctant to use the app. Frequent users rated usability and learnability higher, indicating that familiarity with the app contributed to a more positive experience.

Overall, the results of the work package 4 of the 4D project highlight the potential of mobile technology to transform practice-based learning in clinical education. By aligning mobile applications with educational goals and the practical needs of healthcare institutions, the project successfully demonstrated that digital tools could enhance both the structure and quality of learning in clinical placements. The outcomes suggest that with continued support, resources, and institutional buy-in, mobile technology can play a critical role in preparing healthcare students for the complex demands of clinical practice.

In summary, the pilot study demonstrated the potential of the LTB and LGW to support structured clinical education through digital means, though there are notable areas for improvement, particularly in user experience, communication, and mentor involvement. The feedback suggests that refining usability, providing robust training, and enhancing mentor-student interaction could increase the effectiveness and satisfaction associated with these digital tools in clinical education.

6.1. Recommendations

Based on the 4D project findings, the following recommendations aim to guide institutions in effectively integrating mobile technology into clinical education for enhanced practice-based learning experiences:

- **Develop Customizable Digital Learning Tools:** Institutions should invest in mobile applications, such as the Learning Toolbox and Learning Goal Widget, which can be used to support clinical education in practice placements. These tools should support onboarding, documentation, assessment, and reflective practices, with functionalities that are adaptable to the specific needs of each institution.
- **Conduct Institutional Needs Assessments:** Perform a SWOT analysis (Strengths, Weaknesses, Opportunities, and Threats) of each clinical placement environment to identify unique requirements and challenges. Insights from these analyses can inform the customization of digital tools and help create a targeted digital learning strategy.
- **Prioritize Comprehensive Training for All Stakeholders:** Develop training resources, such as feedback and reflective practice guides, to support both students and mentors in using digital learning tools. Training sessions should address any technological barriers and ensure that users feel comfortable navigating the tools, maximizing their educational benefit.
- **Foster Collaborative Knowledge Exchange:** Facilitate regular workshops or collaborative sessions where students, educators, and mentors can share best practices, discuss challenges, and suggest improvements to digital tools. Such exchanges strengthen institutional partnerships and foster a culture of continuous improvement.
- **Create Sustainable Implementation and Maintenance Plans:** Establish a long-term strategy for the deployment of digital tools, ensuring technical support and maintenance resources are in place. Clear implementation guidelines should also be provided to support the integration of mobile tools into the curriculum seamlessly.
- **Emphasize Structured Reflection and Feedback:** Incorporate tools for structured reflection and regular feedback within digital applications to enable students to assess their progress and develop self-evaluation skills. Establish processes where mentors provide timely, actionable feedback, promoting a supportive learning environment.
- **Align Digital Learning Goals with Clinical Objectives:** Ensure that mobile learning goals are explicitly tied to the clinical competencies and objectives of the placement. By setting clear expectations and aligning digital activities with practical requirements, institutions can help students connect theoretical knowledge with hands-on practice effectively.
- **Monitor** and Gather Feedback on Technology Use: Collect continuous feedback from students, mentors, and other stakeholders on the effectiveness of the mobile tools to refine and enhance their functionality. Regular evaluations will support the technology's adaptability, relevance, and responsiveness to the evolving needs of healthcare education.

By following these recommendations, healthcare institutions can create a structured, engaging, and technology-enhanced learning environment that aligns with the dynamic needs of clinical education.

Based on the pilot study results of the 4D Mobile Apps (the LTB stacks) and Learning Goal Widget (LGW) in clinical education, the following recommendations aim to optimize these tools for better usability, effectiveness, and user satisfaction in practice-based learning:

- **Enhance Usability and User Interface:** Streamline the navigation and simplify the layout of the 4D Mobile Apps (the LTB stacks) and LGW to reduce complexity and improve accessibility. Incorporate user feedback to address common issues such as slow performance and difficulty locating features. An improved, intuitive design will facilitate faster onboarding and a smoother user experience.
- **Improve Reflective Practice Features:** Refine the reflection and self-assessment modules to provide clearer guidance and foster confidence. Create tutorials or mini-guides to help students

engage with reflective practices effectively. Ensure that these features are straightforward and reinforce positive learning outcomes without diminishing students' confidence.

- **Strengthen Communication Channels with Mentors:** Establish better communication features within the app to enable consistent, real-time interaction between students and mentors. Consider adding chat functionality, messaging notifications, or scheduling tools to improve mentor accessibility and responsiveness. This will support ongoing feedback and guidance, enhancing the mentorship experience.
- **Foster Mentor Engagement and Familiarity with the App:** Provide mentors with training to promote regular use of the LTB and LGW and emphasize their role in the app's effectiveness. Address common mentor concerns and offer practical solutions, such as tailored workshops, to enhance their engagement and ease in using the app for student evaluations and feedback.
- **Support Self-Assessment and Goal Tracking:** Make self-assessment and goal-tracking features more accessible and engaging. Simplify the self-assessment process, allowing students to track progress and reflect on learning goals without complexity. Visual progress indicators and customizable goal-setting options could increase students' motivation and ease of use.
- **Focus on Long-Term Adoption and Integration:** Encourage institutional support for the sustained use of LTB and LGW by integrating these tools into the curriculum across multiple courses and placements. Collect continuous feedback to refine the app's relevance to real-world clinical tasks, ensuring it becomes a central tool for students and mentors alike.
- **Address Technical and Connectivity Concerns:** Improve the app's performance to ensure reliability in varied clinical settings, including free and reliable internet access in clinical settings and data-saving options. By optimizing the app for seamless operation even in limited connectivity environments, students can access resources and document their progress without disruption.
- **Gather Ongoing Feedback and Implement Iterative Improvements:** Establish a feedback loop involving students and mentors to gather insights on app usability and functionality regularly. Use this input to make iterative improvements, creating a tool that evolves in line with the needs of both students and healthcare institutions.

Implementing these recommendations can enhance the LTB and LGW's role in clinical education, creating a digital learning environment that aligns more closely with students' learning objectives and mentors' support needs, ultimately strengthening practice-based learning outcomes.

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