

STAYinBowling
Sensor based Training for Athletes and Youngsters in Bowling

D4.1 – Evaluation methodology, plan and results

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Executive Summary

This document outlines the evaluation methodology, planning, and results of the STAYinBowling project, aimed at enhancing the training of bowling athletes and enthusiasts through innovative digital solutions. The project has three primary deliverables: a gamified e-learning platform (MOOC), an IoT toolbox for skill enhancement, and a data visualization dashboard. These solutions target new athletes, coaches, and bowling enthusiasts, fostering skill development, collaboration, and data-driven training methods.

The results of the evaluation process demonstrate positive user feedback on the MOOC's structure, content, and multimedia design, as well as the IoT toolbox's usability and effectiveness. Recommendations include integrating feedback for further improvements and exploring advanced features, such as data integration across tools for enhanced training insights.

This comprehensive evaluation underscores the project's success in combining technology and sports training while providing actionable insights for continuous enhancement.

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1 Introduction

This Deliverable includes the results of all tasks of WP4, namely:

- Evaluation methodology & plan
- Technical validation & expert evaluation
- Coaches' training
- Pilot with target groups
- Technical support & Help Desk
- End users' evaluation

According to the above, main parts of this deliverable will be:

(a) Evaluation methodology & plan:

The evaluation methodology & plan (evaluation framework) is a report that describes the instruments (i.e., questionnaires, log files) that will be used.,

(b) Expert Evaluation Report: It described the results of the technical and expert evaluation that has been conducted, and more specifically:

- Content Review: Experts assessed and refined the MOOC content for technical accuracy and usability.
- Technical Validation: Feedback was collected on the IoT toolbox (Step Tracking and Hand Tracking applications), focusing on improving functionality and usability.

(c) Pilot Usage & End Users' Evaluation Report and Results: This part describes the results of the digital services usage and evaluation by the end users, and more specifically:

- Target groups evaluated the MOOC and IoT toolbox, providing insights into usability, learning outcomes, and the overall user experience.
- Questionnaires assessed key factors such as ease of use, learning impact, and satisfaction.

2 STAYinBowling implementation methodology

For the better understanding of the evaluation methodology, this chapter is presenting the project implementation methodology (as described in the project proposal).

The project has three main outcomes:

- **O1:** To design and develop digital content, for supporting the deployment of learning activities, through a **gamified e-learning platform**. This content will be integrated and accessed as a **European Massive Open Online Course (MOOC)** for new bowling athletes and anyone interested in the bowling game, embracing a de-centralized model of diversity, open access, equity and quality. The MOOC will become a **collaborative community of practice** for Bowling Coaches, Young and Experienced Bowling athletes and former athletes to share, discuss and collaborate information about the techniques that should be used while playing bowling.
- **O2:** To design and develop a **digital Internet of Things (IoT) toolbox** that will be exploited by the bowling coaches to support the new athletes. The IoT toolbox will be in the form of sensors used by the athletes while playing, accompanied by applications to view several stats and get instantaneous feedback to self – regulate.
- **O3:** To design and develop a **dashboard** to display the acquired data related to the feet and hand movement while playing bowling in a dashboard. This website will have summative graphs for all the athletes and personalized ones. The dashboard will be used to support the IoT toolbox.

The project methodology is following three directions based on well-known approaches in each direction.

(A) The **first direction** concerns the creation of a MOOC for educating new bowling athletes. To this direction the project will follow the **EADTU – Business model for lifelong learning** (EDATU, 2010) and more specifically the following phases:

- **Mission, vision and value:** Widening access, adapting to the needs, adopt specific programmes to attract new adult learners, etc.
- **Objectives** both internally and externally in relation to stakeholders, learners and society in general
- **Strategic analysis:** opportunities and threats
- **Market analysis:** other providers, learners' expectations, employers and employees' needs
- **Production and delivery** of courses/programmes adapted to these needs.

STAYinBowling has adopted the following phases: Collection of user requirements about the program of studies; Creation of the program of studies; Expert evaluation of the Syllabus, Learning Outcomes; Creation of the educational content; Pilot evaluation and refinement

(B) The **second direction** concerns the instructional design and the development of digital services.

To this direction the project will follow the **ADDIE** (U.S. Air Force, 1970) Instructional Systems Design (ISD) model), which is a framework that lists generic processes that instructional designers and training developers use. It represents a guideline for building effective training and performance support tools in five phases:

- **Analysis:** the instructional problem is clarified; the instructional goals and objectives are established; and the learning environment and learner's existing knowledge and skills are identified
- **Design:** The design phase deals with learning objectives, assessment instruments, exercises, content, subject matter analysis, lesson planning and media selection. The design phase should be systematic and specific
- **Development:** The development phase is where instructional designers and developers create and assemble the content assets that were blueprinted in the design phase. In this phase, storyboards are created, content is written, and graphics are designed. If learning is involved, programmers work to develop and/or integrate technologies
- **Implementation:** During the implementation phase, a procedure for training the facilitators and the learners is developed. The facilitators' training should cover the course curriculum, learning outcomes, method of delivery, and testing procedures
- **Evaluation:** The evaluation phase consists of two parts: formative and summative. Formative evaluation is present in each stage of the ADDIE process. Summative evaluation consists of tests designed for domain specific criterion-related referenced items and providing opportunities for feedback from the users which were identified.

(C) The **third direction** concerns the educational evaluation of the above outcomes (namely, the effectiveness strategies, the MOOC & the digital services – mobile serious games). To this direction the project will follow **Kirkpatrick's training evaluation model** (Kirkpatrick, 1959), for measuring (a) the **Reaction** (i.e. to what degree participants react favorably to the training); (b) **Learning** (i.e. to what degree participants acquire the intended knowledge, skills, attitudes, confidence and commitment based on their participation in a training event);

3 Evaluation Methodology

This chapter outlines the evaluation methodology for the STAYinBowling project, focusing on its curriculum and digital services. It comprises two phases: expert validation which mainly includes content review and formative feedback for the digital services, as well as user feedback, targeting usability and the impact of the MOOC and the IoT toolbox. The following sections detail the evaluation phases, tools, and target groups involved.

3.1 Evaluation Goals

As described in the STAYinBowling proposal, the main objective of the STAYinBowling evaluation is the deployment and assessment of the MOOC and digital services by end-users in the pilot sites, with a focus on their impact on their way of playing bowling.

Before user evaluation, the MOOC and the IoT toolbox were reviewed by experts.

Therefore, the STAYinBowling evaluation consists of three phases (Figure 1):

- Phase A: Formative Experts' Evaluation of the STAYinBowling content in the MOOC
- Phase B: Formative Experts' Technical Validation of the STAYinBowling IoT toolbox
- Phase C: Summative User's Evaluation of the STAYinBowling IoT toolbox and MOOC

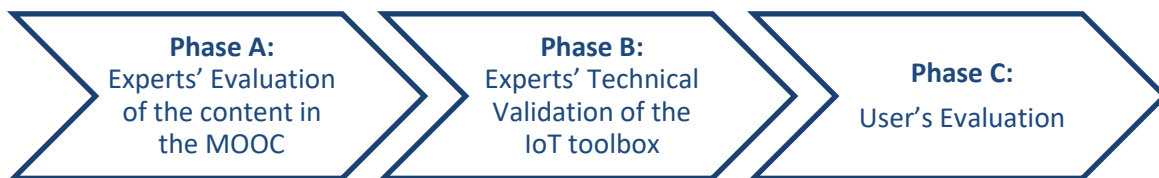


Figure 1 STAYinBowling evaluation phases

The goals/research questions for each phase of the evaluation are the following:

- **Phase A:** Formative Experts' Evaluation of the MOOC content
 - **A_G1:** Expert evaluation of the MOOC content to identify and correct errors
- **Phase B:** Formative Experts' Technical Validation of the IoT toolbox
 - **B_G1:** Experts qualitative feedback after using the IoT toolbox apps
- **Phase C:** Summative Users' Evaluation of the STAYinBowling IoT toolbox and MOOC
 - **C_G0:** What is the users' opinion about their knowledge improvement by using the MOOC?
 - **C_G1:** What is the users' opinion about segmenting, sequencing and navigation of the educational material MOOC course?
 - **C_G2:** What is the users' opinion about MOOC Learning Content?
 - **C_G3:** What is the user's opinion about the design of text, graphics and videos of the MOOC?

- **C_G4:** What is the Impact of the course/ STAYinBowling solution to your way of playing bowling?
- **C_G5:** What is the users' overall opinion about STAYinBowling MOOC platform?
- **C_G6:** What is the users' perceived Usefulness of the Step Tracking Application?
- **C_G7:** What is the users' perceived Ease of Use of the Step Tracking Application?
- **C_G8:** What is the users' perceived Ease of Learning of the Step Tracking Application?
- **C_G9:** What is the users' perceived Satisfaction of the Step Tracking Application?
- **C_G10:** What is the users' perceived Usefulness of the Hand Tracking Application?
- **C_G11:** What is the users' perceived Ease of Use of the Hand Tracking Application?
- **C_G12:** What is the users' perceived Ease of Learning of the Hand Tracking Application?
- **C_G13:** What is the users' perceived Satisfaction of the Hand Tracking Application?

3.2 Instruments / Methods

This section presents the method and the instruments that will be used in each evaluation phase.

Regarding the first evaluation phase, where formative feedback will be provided to the development team regarding the applications of the IoT toolbox, a focus group with coaches from the consortium partners. The purpose of the focus group is to engage bowling coaches to evaluate the functionality and usability of the applications, providing actionable insights for improvement.

During, Phase B, peer to peer internal evaluation will be conducted by experts from the consortium. The purpose of the evaluation is to assess the quality of the MOOC, the appropriateness of the learning objectives and the learning tools selected to facilitate learning. After going through the whole MOOC, the current version of the MOOC content document will be provided to the experts, that should be returned to the development team with comments and track changes, regarding the topics of the course, the contents of each topic, the educational videos and the supporting literature.

Finally, to address the evaluation research questions of the third phase, a few questionnaires will be used.

- An online survey to collect data about the learning content, courses and other aspects of the MOOC in general.
- An online survey to collect data about the IoT toolbox applications' usability while playing bowling.

The following table (Table 1) presents STAYinBowling evaluation instruments for the summative evaluation phase.

Table 1 STAYinBowling evaluation instruments

Instrument	Description	Evaluation Goal
Users' final online MOOC survey (see Appendix I)	Section 1: Knowledge improvement by using the MOOC	G0: What is the users' opinion about their knowledge improvement by using the MOOC?

Instrument	Description	Evaluation Goal
Users' final online MOOC survey (see Appendix I)	Section 2: Segmenting, sequencing and navigation of the course MOOC This section is based on the "Checklist for a Didactically Sound Design of eLearning Content" by Schoor & Körndle (2012).	G1: What is the users' opinion about segmenting, sequencing and navigation of the educational material MOOC course?
Users' final online MOOC survey (see Appendix I)	Section 2: Learning Content This section is based on the "Checklist for a Didactically Sound Design of eLearning Content" by Schoor & Körndle (2012).	G2: What is the users' opinion about MOOC Learning Content?
Users' final online MOOC survey (see Appendix I)	Section 2: Design of text, graphics and videos This section is based on the "Checklist for a Didactically Sound Design of eLearning Content" by Schoor & Körndle (2012).	G3: What is the user's opinion about the design of text, graphics and videos of the MOOC?
Users' final online MOOC survey (see Appendix I)	Section 2: Impact of the course/ STAYinBowling solution to the user's way of playing bowling	G4: What is the Impact of the course/ STAYinBowling solution to your way of playing bowling?
Users' final online MOOC survey (see Appendix I)	Section 2: Overall opinion about project Platform MOOC This section is based on the survey of Douka (2001).	G5: What is the users' overall opinion about STAYinBowling MOOC platform?
Users' final IoT toolbox evaluation (see Appendix II)	Section 1: Perceived Usefulness (No. 1-5) This section is based on the questionnaire used in the paper by Lund (2001).	G6: What is the users' perceived Usefulness of the Step Tracking Application? G10: What is the users' perceived Usefulness of the Hand Tracking Application?
Users' final IoT toolbox evaluation (see Appendix II)	Section 1: Perceived Ease of Use (No. 6-9) This section is based on the questionnaire used in the paper by Lund (2001).	G7: What is the users' perceived Ease of Use of the Step Tracking Application?

Instrument	Description	Evaluation Goal
		G11: What is the users' perceived Ease of Use of the Hand Tracking Application??
Users' final IoT toolbox evaluation (see Appendix II)	Section 1: Perceived Ease of Learning (No. 10-12) This section is based on the questionnaire used in the paper by Lund (2001).	G8: What is the users' perceived Ease of Learning of the Step Tracking Application? G12: What is the users' perceived Ease of Learning of the Hand Tracking Application?
Users' final IoT toolbox evaluation (see Appendix II)	Section 1: Perceived Satisfaction (No. 13-17) This section is based on the questionnaire used in the paper by Lund (2001).	G9: What is the users' perceived Satisfaction of the Step Tracking Application? G13: What is the users' perceived Satisfaction of the Hand Tracking Application?

The primary target group of the project is people interested in bowling that want to improve their skills (e.g. athletes) or people that want to train others more effectively (e.g. coaches): (a) New athletes; (b) Bowling coaches; (c) Bowling fans and anyone interested in the bowling game. The secondary target group is adolescents/youngsters in all over the Europe.

4 Evaluation Plan

The evaluation plan has the following important steps and phases (see Figure 2) according to STAYinBowling WP4 Tasks:

- **Step 1** (finished in M11): Finalization of evaluation methodology, instruments, goals
- **Step 2** (during M12-M13): **Evaluation Phase A**: Formative Experts' Technical Validation of the STAYinBowling digital services, focused on the MOOC content and platform
- **Step 3** (during M13-M16): Pilot with target groups, that is connected to the **Evaluation Phase B**: Experts' Technical Validation of the IoT toolbox
- **Step 4** (during M16-M22): Mobilization of users, including the project Multiplier Event II
- **Step 5** (during M16-22): **Evaluation Phase C**: Summative User's Evaluation of the STAYinBowling digital services
- **Step 6** (finished in M23): Reporting of evaluation results

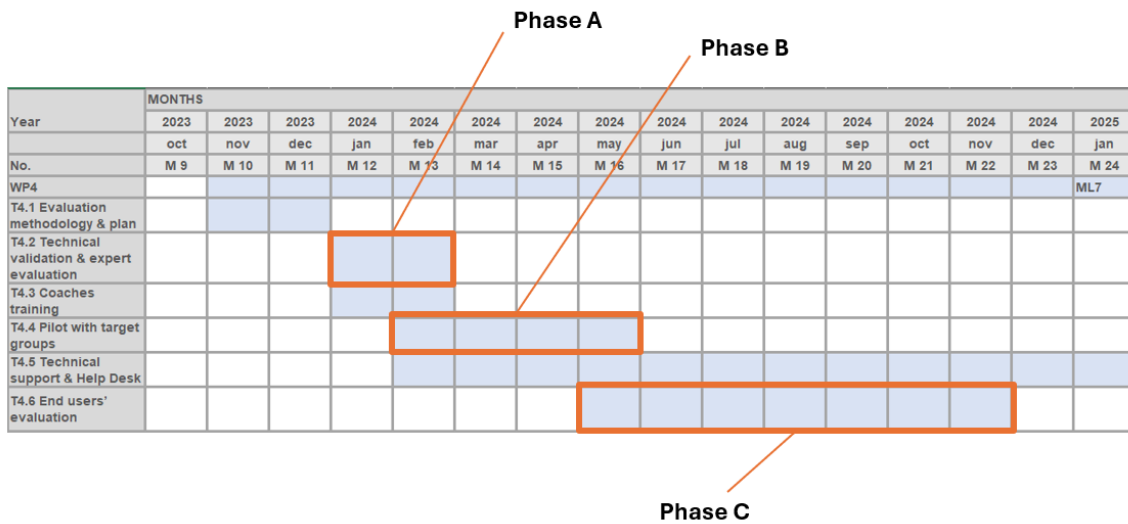


Figure 2 STAYinBowling Project Plan

5 Expert Evaluation

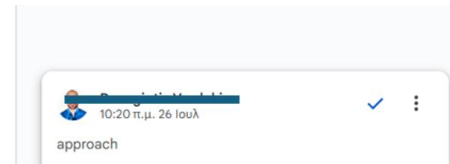
5.1 Experts' Evaluation of the MOOC Content

Short after creating the content for the MOOC a virtual meeting was held introducing the textbook that would be digitalized in the MOOC. As this evaluation phase was an internal one, bowling experts from TEN PIN and MBA proceeded into making a few remarks and changing the content.

Most of the changes were about typos and the bowling terminology used throughout the text. Some of the proposed changes can be found in the following figures.

Try this exercise to work on your approach:

1. Practice your four-step **release**, focusing on your timing and balance by tracking key points/factors mentioned above.



The width of your steps determines your balance and stability during the approach. Proper step width helps maintain control and consistency in your shots. First step is a normal step ~~and a bit smaller~~. The second step is a ~~bit bigger and faster~~ is a normal step and the third step is ~~and quick~~ is and quick ~~small~~. Your slide can be extensive/long if your balance persists. Losing balance during the |

Figure 3 Examples of correcting typos and terminology in the MOOC content

Finally, some of the comments focused on the level of expertise that one should have to fully understand what's written so they were removed, as seen in the following figure.

- **Balance Board or Stability Disc (Not for beginners):** ~~balance~~
~~Board or Stability Disc:~~
 - Incorporate a balance board or stability disc into your training. These tools challenge your stability and can improve your balance over time.
- balls.
- **High RG (Radius of Gyration) Core:**
 - Higher RG cores have a more extended, flatter shape.
 - Delays the ball's transition to hooking, providing a later and smoother reaction.
 - Often used in balls designed for drier lane conditions.
- **Low RG Core:**
 - Lower RG cores are more compact and denser.
 - Promotes an earlier and more aggressive hook.
 - Well-suited for heavy oil conditions and bowlers seeking a strong overall motion.

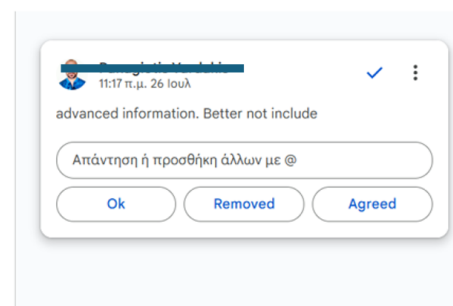
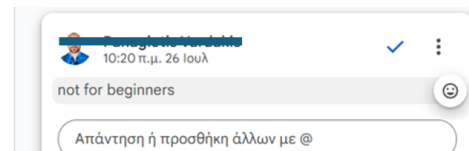


Figure 4 Examples of proposed changes due to level of expertise in the MOOC content

5.2 Experts' Technical Validation of the STAYinBowling IoT toolbox

The technical validation of the STAYinBowling IoT toolbox was conducted internally with experts of the consortium. The consortium gathered feedback on the applications included in the IoT toolbox, specifically the Hand Tracking and Step Tracking applications, after coaches used early versions of these applications in the field.

Regarding the Step Tracking application, several modifications were proposed to improve its precision and enhance the coach's control over the player's bowling practice. It was decided to add a start and stop functionality, which would allow the coach to have full control over the tracking process. Additionally, while the direction of the steps during the approach in bowling practice was found to be useful, the visual presentation of this data was considered a nice-to-have feature rather than an essential one. Furthermore, coaches requested the ability to select the athlete before their throw and maintain that selection until the coach specifies otherwise. Another suggestion was to enlarge the information panel to make it easier for instructors to read on the smaller screen of a smartphone.

For the Hand Tracking application, a few changes were also proposed to improve accessibility.

Additionally, feedback was gathered regarding the need for an ideal unified application that would combine the functionalities of all the applications in the toolbox. This idea is not yet within the scope of the current project, as the applications have not been fully verified for their usefulness to bowling athletes and coaches. However, the integration of sensor data could provide valuable insights for coaches, particularly for guiding the athlete during the approach to the foul line and potentially during the ball swing. A significant limitation, however, is that the sensors currently use the same interface to connect to the mobile application, which would necessitate finding new ways to connect the sensors to the device. An accompanying camera would also be beneficial for the Step Tracking application, as it could enable coaches to review videos of the player's steps and possibly combine sensor data with video footage. If the two applications were integrated, it would allow for the identification of the moment of maximum acceleration during the ball swing.

In terms of the dashboard, it was noted that it effectively presents the data gathered from the applications in a clear and user-friendly manner, and participants in the meeting found it useful. However, it was decided that the data sharing should be more restricted than initially implemented. Instead of making all data accessible to everyone, it was determined that athletes should only have access to their own hand and step tracking data. Coaches should have access only to the data of their respective athletes, rather than all registered athletes.

6 End Users' Evaluation: Participants demographics

This section presents information related to the demographics of the participants that were enrolled in the STAYinBowling MOOC and that took place in the summative evaluation.

6.1 Enrolled users in MOOC

Users were able to register to the STAYinBowling MOOC Platform till the final days of the evaluation phase.

At the end of the evaluation phase, 72 users were registered to STAYinBowling Massive Open Online Course. The total number of users are described below in Table 2 and Figure 5.

Table 2 Total Number of user per country in MOOC

Country	Participants
Greece	45
Malta	25
Others	2
Total	72

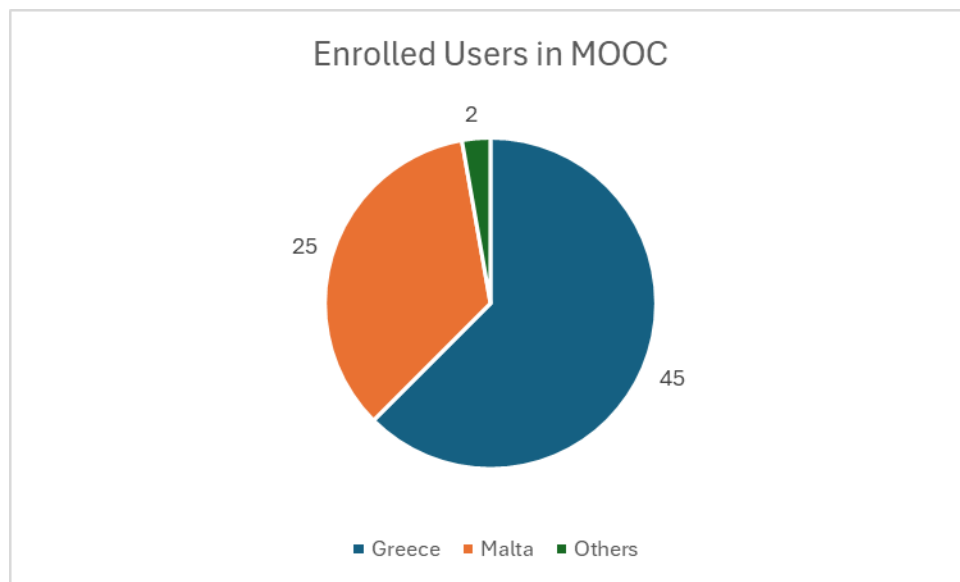


Figure 5 Graph showcasing the Numbers of Users per country in MOOC

6.2 Users evaluating the tools

At the end of the end users' evaluation phase 76 users had successfully evaluated the STAYinBowling digital services. The population consists of people coming from each from the consortium countries. In particular 64 participants are from Greece and 12 participants are from Malta. 28% of the participants were female (Figure 6), while 71% were male and 1% identified as other.

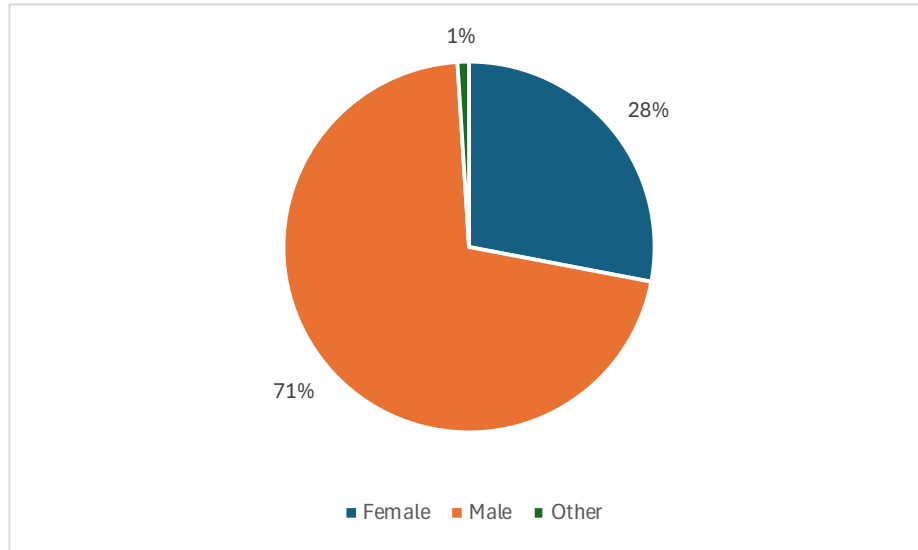


Figure 6 Sample of participants according to their gender

Although the age distribution of the participants was diverse (Figure 7), the age groups of 36-50 and 51-65 years (28% of the total respectively) comprised the majority. The remaining participants comprised 18% those aged 18-20, 21% of those aged 21-35, 5% of those aged 66-80 and 1% was aged over 80.

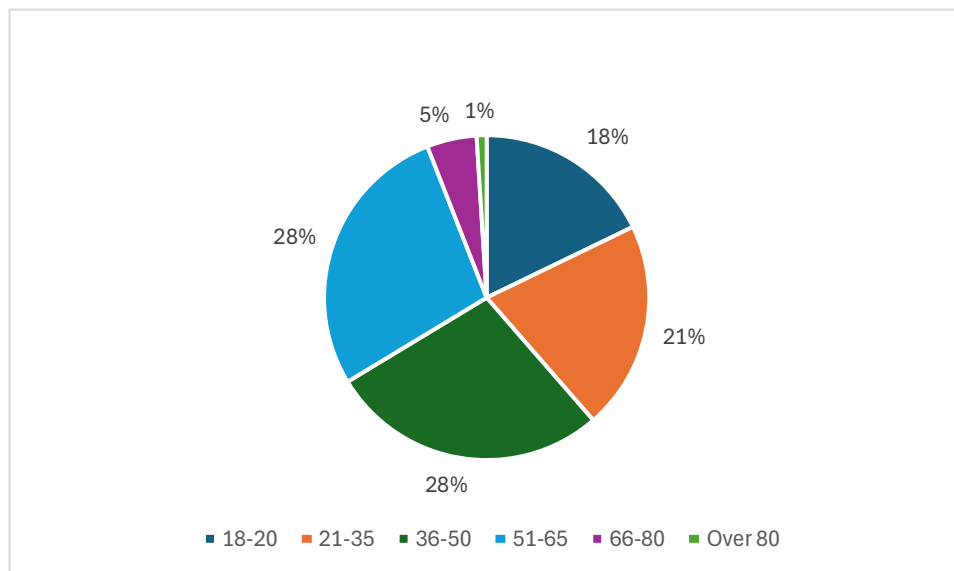


Figure 7 Sample of participants according to their age

The participants academic credentials (Figure 8) were also diverse. Most of the participants were High school graduates (33%) whilst only a few of them didn't complete their schooling or had no diploma (9% respectively).

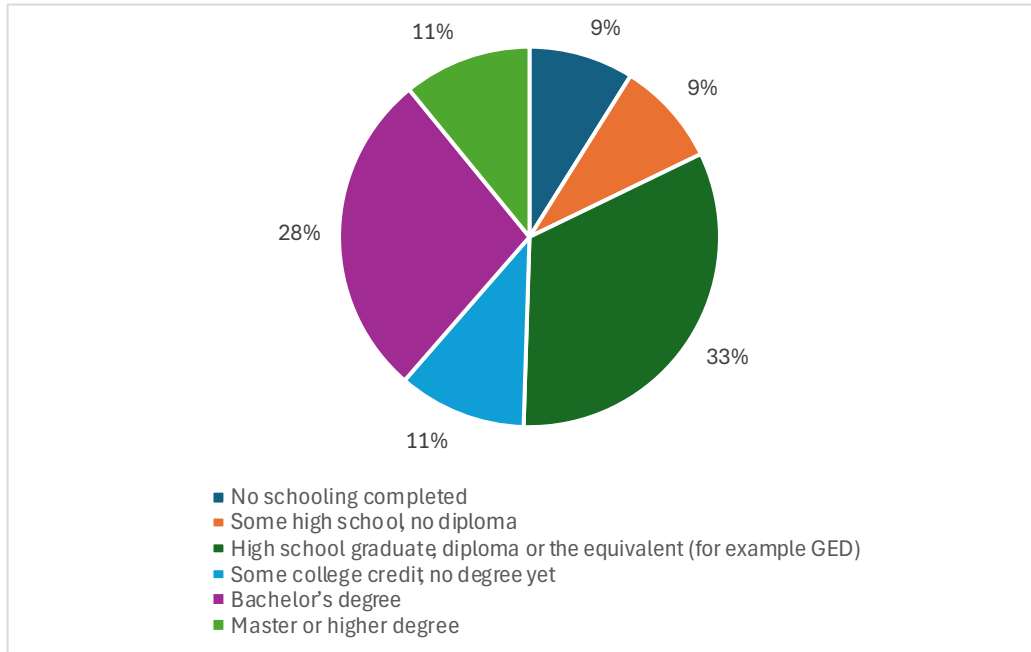


Figure 8 Sample of participants according to their level of education

Finally, most of the participants identified themselves as amateur athletes (61%) as seen in Figure 9. Some of the participants identified themselves as professional athletes (13%) and equal parts of the participants were coaches, students and other (8%). None of the participants were physical education teachers.

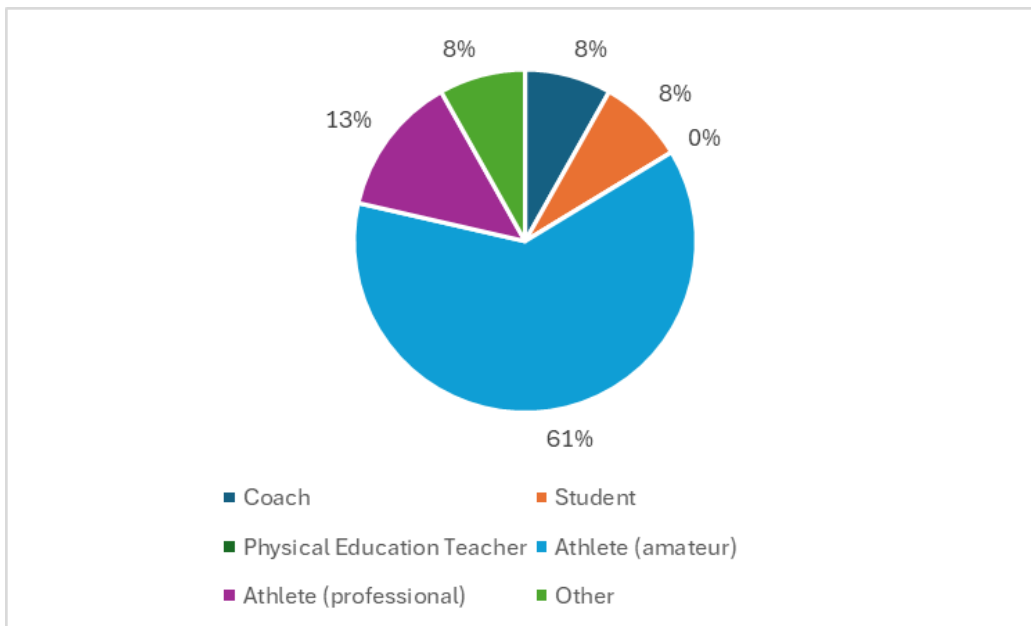


Figure 9 Sample of participants' profile

7 End Users' Evaluation of the MOOC

This chapter will present the results of the evaluations by the users of the MOOC platform, through the scales that assess each of the 5 sections. The evaluation was about their knowledge improvement, the segmenting and sequence of the MOOC, the learning content, the design of text, graphics and videos, the impact of the course and their overall opinion about the course.

7.1 G0: What is the users' opinion about their knowledge improvement by using the MOOC?

Respondents were asked to fill in a five-point Likert scale their knowledge improvement after using the STAYinBowling MOOC. According to the results most of the participants feel that they have improved their knowledge regarding bowling as more than half of them answered that they agree or strongly agree with the statements shown to them.

Table 3 Descriptive analysis with percentages of the items under the scale "Knowledge Improvement"

Responses	1	2	3	4	5	Mean Value
The STAYinBowling MOOC increases my knowledge about bowling.	3%	3%	13%	50%	30%	4
I catch the basic ideas of the knowledge taught about bowling.	3%	3%	13%	40%	40%	4.1
I try to apply the knowledge about bowling.	3%	13%	10%	47%	27%	3.8
I want to know more about the bowling.	3%	0%	17%	30%	50%	4.23

In particular the item with the highest mean of 4.23 (SD=.97) was the "I want to know more about the bowling" whilst the lowest rated with a mean of 3.8 (SD=1.1) was the "I try to apply the knowledge about bowling".

7.2 G1: What is the users' opinion about segmenting, sequencing and navigation of the educational material MOOC course?

Respondents were asked to evaluate aspects of the course structure using a five-point Likert scale. According to the results, most participants found the course well-organized, with a majority agreeing or strongly agreeing with the statements provided.

Table 4 Descriptive analysis with percentages of the items under the scale "Segmenting, Sequencing and Navigation of the Educational Material"

Responses	1	2	3	4	5	Mean Value
Is the content segmented adequately (neither too wide nor too narrow)?	3%	0%	20%	43%	33%	4.03
Is the sequencing well structured?	3%	3%	13%	37%	43%	4.13

In particular, the item with the highest mean of 4.13 (SD=0.98) was “Is the sequencing well structured?”, indicating strong approval of the course's progression and flow.

7.3 G2: What is the users' opinion about MOOC Learning Content?

Respondents were asked to evaluate the learning content of the MOOC in relation to various aspects of their bowling experience and learning goals using a five-point Likert scale. The results indicate overall satisfaction, with most participants agreeing or strongly agreeing with the statements.

Table 5 Descriptive analysis with percentages of the items under the scale “Opinion about the Learning Content”

Responses	1	2	3	4	5	Mean Value
The MOOC is suitable for me regarding my play in bowling	3%	3%	17%	43%	33%	4
The MOOC is suitable for me regarding my prior knowledge on bowling	3%	7%	23%	23%	43%	3.97
The MOOC is suitable for my learning goals	3%	3%	20%	43%	30%	3.93
The learning objectives and topics are clearly defined	0%	7%	10%	33%	50%	4.27
The multimedia material facilitated the study of the topics	3%	7%	17%	33%	40%	4
The multimedia material was informative enough	3%	7%	17%	27%	47%	4.07

The highest-rated item, with a mean of 4.27 (SD=.91) was “The learning objectives and topics are clearly defined,” reflecting a strong consensus on the clarity of the course structure. The item “The multimedia material was informative enough” followed closely, with a mean value of 4.07 (SD=1.11), indicating that the materials provided were generally seen as helpful and comprehensive.

On the other hand, the lowest-rated item, “The MOOC is suitable for my learning goals,” received a mean of 3.93 (SD=0.98), suggesting that while most respondents were satisfied, a small proportion found room for improvement in aligning the MOOC with their specific goals.

7.4 G3: What is the user's opinion about the design of text, graphics and videos of the MOOC?

Respondents were asked to assess the quality and comprehensibility of the MOOC's textual and multimedia materials using a five-point Likert scale. The results reveal a generally positive perception, with the majority agreeing or strongly agreeing with the provided statements.

Table 6 Descriptive analysis with percentages of the items under the scale “Design of Text, Graphics and Videos”

Responses	1	2	3	4	5	Mean Value
Texts were readable	7%	0%	17%	23%	53%	4.17
Texts were understandable	10%	7%	10%	20%	53%	4
Graphics were understandable	7%	3%	7%	27%	57%	4.23
The quality of graphics was high	7%	3%	10%	27%	53%	4.17
Graphics and video were readable	10%	0%	7%	37%	47%	4.1
Videos were understandable	7%	3%	7%	27%	57%	4.23
The quality of videos was high	7%	3%	7%	43%	40%	4.07
Videos were easy to follow	7%	3%	13%	20%	57%	4.17

The highest-rated items, both with a mean of 4.23 (SD=1.17), were “Graphics were understandable” and “Videos were understandable,” indicating that these elements were particularly effective in conveying information. Similarly, statements such as “Texts were readable” and “Videos were easy to follow” received great evaluations highlighting the accessibility of these materials.

However, the lowest-rated item, “The quality of videos was high,” received a mean of 4.07 (SD=0.97). While still positive, this suggests that a small percentage of respondents saw potential for improvement in video production quality.

7.5 G4: What is the Impact of the course/ STAYinBowling solution to your way of playing bowling?

Respondents were asked to evaluate the impact of the course on their bowling performance using a five-point Likert scale. The results show mixed but generally positive perceptions, with the majority agreeing or strongly agreeing with the statements provided.

Table 7 Descriptive analysis with percentages of the items under the scale “Impact to Bowling Performance”

Responses	1	2	3	4	5	Mean Value
This course will change my way of playing bowling	7%	0%	20%	63%	10%	3.7
The degree of the change in playing bowling will be high due to this course	3%	10%	20%	57%	10%	3.6
This course will improve my way of playing bowling	3%	7%	10%	50%	30%	3.97

The highest-rated item, with a mean of 3.97 (SD=1.0), was “This course will improve my way of playing bowling,” indicating that participants largely felt the course would enhance their skills.

In contrast, the item “The degree of the change in playing bowling will be high due to this course” received the lowest mean of 3.6 (SD=.93), suggesting that while some respondents expected improvements, they were less confident about the magnitude of change the course would bring.

7.6 G5: What is the users’ overall opinion about STAYinBowling MOOC platform?

Respondents were asked to rate various attributes of the course using a five-point Likert scale. The results indicate that participants had a largely positive perception of the course, with high ratings across multiple aspects.

Table 8 Descriptive analysis with percentages of the items under the scale “Overall Opinion about the MOOC”

Responses	1	2	3	4	5	Mean Value	SD
Comprehensive	7%	3%	3%	50%	37%	4.07	1.08
Perceivable	7%	3%	10%	43%	37%	4	1.11
Educational	3%	13%	10%	17%	57%	4.1	1.24
Easy	3%	3%	23%	27%	43%	4.03	1.07
Enjoyable	3%	3%	10%	43%	40%	4.13	0.97
Interesting	3%	3%	13%	30%	50%	4.2	1.03
Satisfactory	3%	3%	13%	33%	47%	4.17	1.02
Well done	3%	0%	13%	33%	50%	4.27	0.94
Scientific	3%	13%	17%	30%	37%	3.83	1.18
Serious	7%	3%	13%	23%	53%	4.13	1.2
Well prepared	3%	13%	10%	17%	57%	4.1	1.24
Important	7%	7%	13%	43%	30%	3.83	1.15
Innovative	3%	3%	3%	47%	43%	4.23	0.94
Modern	3%	0%	7%	47%	43%	4.27	0.87
Pedagogical	3%	7%	17%	23%	50%	4.1	1.12
Well-targeted	3%	7%	10%	13%	67%	4.33	1.12
Different	3%	0%	10%	30%	57%	4.37	0.93

Respondents were asked to rate various attributes of the course using a five-point Likert scale. The results indicate that participants had a largely positive perception of the course, with high ratings across multiple aspects.

The highest-rated item, with a mean of 4.37 (SD=0.93), was “Different,” suggesting that participants found the course to stand out in its approach or content. Other highly rated attributes included “Well-targeted” (Mean = 4.33, SD=1.12) and “Modern” (Mean = 4.27, SD=0.87), highlighting the relevance and up-to-date nature of the course materials. Similarly, “Well done” (Mean = 4.27, SD=0.94) reflected strong overall satisfaction with the course quality.

Attributes such as “Enjoyable” and “Serious” both received a mean of 4.13 (SD=0.97 and 1.2, respectively), showing a balance between engagement and professionalism. “Pedagogical,” “Educational,” and “Well prepared” each had a mean of 4.1, emphasizing the course’s effectiveness in achieving its instructional goals.

Conversely, the lowest-rated items, “Scientific” and “Important,” both had a mean of 3.83 (SD=1.18 and 1.15, respectively), suggesting that while still positively viewed, some respondents found these aspects less prominent compared to others.

8 End Users' Evaluation of the IoT Toolbox

8.1 Step Tracking Application Evaluation

8.1.1 G6: What is the users' perceived Usefulness of the Step Tracking Application?

Participants were required to rate their perceived usefulness of the Step Tracking Application using a seven-point Likert scale, as described by Lund (2001). The results reveal overall positive impressions, with most participants rating the usefulness of the application highly. The overall mean value of the was 5.06 indicating that the participants felt that the application was useful.

Table 9 Descriptive analysis with percentages of the items under the scale "Usefulness" of the Step Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
It helps me be more effective.	4%	4%	4%	18%	14%	32%	25%	5,32
It helps me be more productive	4%	7%	7%	11%	25%	29%	18%	5,04
It is useful.	4%	7%	4%	11%	21%	21%	32%	5,32
It gives me more control over the activities in my life.	4%	7%	4%	29%	21%	25%	11%	4,75
It makes the things I want to accomplish easier to get done	4%	7%	4%	18%	25%	39%	4%	4,86

The highest-rated items, both with a mean of 5.32, were "It helps me be more effective" and "It is useful," indicating that participants strongly felt the application contributed to their efficiency while playing bowling.

The lowest-rated item, "It gives me more control over the activities in my life," received a mean of 4.75, indicating that some respondents felt the application was less influential in this area.

8.1.2 G7: What is the users' perceived Ease of Use of the Step Tracking Application?

Respondents were asked to evaluate the perceived ease of use of the Step Tracking Application using a seven-point Likert scale, following the approach outlined by Lund (2001). The results indicate generally favorable opinions, with most participants agreeing that the application is easy to use. The overall mean value was 5.19, reflecting a positive perception of its usability.

Table 10 Descriptive analysis with percentages of the items under the scale "Ease of Use" of the Step Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
It is easy to use.	4%	0%	11%	21%	21%	4%	39%	5.25
It is simple to use.	4%	0%	11%	14%	21%	18%	32%	5.32

It is user friendly.	4%	4%	7%	14%	21%	21%	29%	5.25
It requires the fewest steps possible to accomplish what I want to do with it.	4%	0%	4%	39%	14%	25%	14%	4.93

The highest-rated item, with a mean of 5.32, was “It is simple to use,” demonstrating that participants appreciated the straightforwardness of the application. Similarly, “It is easy to use” and “It is user friendly” both received a mean of 5.25, further confirming the application's user-oriented design.

In contrast, the item “It requires the fewest steps possible to accomplish what I want to do with it” received a slightly lower mean of 4.93, suggesting that some participants felt there was room for improvement in optimizing task efficiency.

8.1.3 G8: What is the users’ perceived Ease of Learning of the Step Tracking Application?

Participants were invited to assess the ease of learning associated with the Step Tracking Application using a seven-point Likert scale. The results suggest a positive overall perception, with most respondents agreeing that the application is easy to learn and recall. The overall mean value was 5.35, indicating that the learning curve for the application was manageable for most users.

Table 11 Descriptive analysis with percentages of the items under the scale “Ease of Learning” of the Step Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
I learned to use it quickly	4%	0%	4%	32%	14%	18%	29%	5.21
I easily remember how to use it.	4%	7%	0%	18%	21%	18%	32%	5.29
It is easy to learn to use it.	4%	0%	7%	11%	18%	29%	32%	5.54

The highest-rated item, with a mean of 5.54, was “It is easy to learn to use it,” reflecting that participant found the application intuitive and straightforward to pick up. Additionally, the statement “I easily remember how to use it” received a mean of 5.29, underscoring the application's ability to support memory retention in its use.

The item “I learned to use it quickly” had a slightly lower mean of 5.21, suggesting that while most users found the learning process efficient, a few experienced minor delays in getting started.

8.1.4 G9: What is the users’ perceived Satisfaction of the Step Tracking Application?

Participants were asked to rate their satisfaction with the Step Tracking Application using a seven-point Likert scale. The results reveal generally high satisfaction, with most users indicating positive experiences. The overall mean value was 5.16, suggesting that the application met users' expectations in terms of satisfaction.

Table 12 Descriptive analysis with percentages of the items under the scale “Satisfaction” of the Step Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
I am satisfied with it.	7%	7%	0%	11%	21%	32%	21%	5.14
I would recommend it to a friend	4%	4%	7%	18%	21%	21%	25%	5.14
It is fun to use.	4%	7%	7%	14%	21%	21%	25%	5.07
It works the way I want it to work.	4%	4%	0%	21%	21%	29%	21%	5.25
It is wonderful.	4%	7%	4%	14%	25%	18%	29%	5.18

The highest-rated item, with a mean of 5.25, was “It works the way I want it to work,” reflecting that the majority of users found the application to be reliable and aligned with their needs.

On the other hand, the item “It is fun to use” had a slightly lower mean of 5.07, suggesting that while users appreciated the application, some found it less engaging in terms of enjoyment.

8.2 Hand Tracking Application Evaluation

8.2.1 G10: What is the users’ perceived Usefulness of the Hand Tracking Application?

Participants were asked to evaluate the perceived usefulness of the Hand Tracking Application using a seven-point Likert scale. The results reveal an overall positive perception, with most users finding the application beneficial for their needs. The overall mean value was 5.02, indicating that participants generally felt the application was useful in improving their efficiency while playing bowling.

Table 13 Descriptive analysis with percentages of the items under the scale “Usefulness” of the Hand Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
It helps me be more effective.	4%	7%	7%	7%	30%	30%	15%	5
It helps me be more productive	4%	0%	7%	11%	41%	15%	22%	5.19
It is useful.	7%	0%	4%	4%	37%	26%	22%	5.3
It gives me more control over the activities in my life.	7%	0%	7%	26%	19%	37%	4%	4.74
It makes the things I want to accomplish easier to get done	4%	4%	4%	30%	22%	22%	15%	4.89

The highest-rated item, with a mean of 5.3, was “It is useful,” reflecting strong agreement that the application provided value.

On the other hand, the item “It gives me more control over the activities in my life” received the lowest mean of 4.74, suggesting that some users felt the application had a more limited impact on providing control over their tasks while playing bowling.

8.2.2 G11: What is the users’ perceived Ease of Use of the Hand Tracking Application?

Participants were asked to rate the perceived ease of use of the Hand Tracking Application using a seven-point Likert scale. The results show an overall positive response, with users indicating that the application is generally easy to use. The overall mean value was 5.28, suggesting that most users found the application intuitive and straightforward.

Table 14 Descriptive analysis with percentages of the items under the scale “Ease of Use” of the Hand Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
It is easy to use.	7%	0%	11%	7%	22%	26%	26%	5.19
It is simple to use.	4%	0%	4%	4%	33%	33%	22%	5.52
It is user friendly.	4%	4%	4%	11%	26%	30%	22%	5.3
It requires the fewest steps possible to accomplish what I want to do with it.	4%	7%	0%	11%	30%	37%	11%	5.11

The highest-rated item, “It is simple to use,” received a mean of 5.52, reflecting strong approval for the application's simplicity and ease of navigation.

While the other ratings were also positive, “It requires the fewest steps possible to accomplish what I want to do with it” had a slightly lower mean of 5.11, indicating that while users generally found the application efficient, a few felt that certain tasks could be streamlined for a more optimal experience.

8.2.3 G12: What is the users’ perceived Ease of Learning of the Hand Tracking Application?

Participants were asked to assess the ease of use of the Hand Tracking Application using a seven-point Likert scale. The results show that most users found the application to be easy to use, with an overall mean value of 5.28, indicating a favorable perception of its usability.

Table 15 Descriptive analysis with percentages of the items under the scale “Ease of Learning” of the Hand Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
I learned to use it quickly	4%	0%	4%	7%	33%	33%	19%	5.41
I easily remember how to use it.	4%	0%	4%	15%	33%	19%	26%	5.33
It is easy to learn to use it.	4%	4%	7%	11%	30%	22%	22%	5.15

The highest-rated item, with a mean of 5.52, was “It is simple to use,” reflecting a strong consensus that the application’s design was intuitive and straightforward.

The item “It requires the fewest steps possible to accomplish what I want to do with it” received a slightly lower mean of 5.11, suggesting that while users generally found the application efficient, there was a small group who felt it could be further streamlined for even greater ease of use.

8.2.4 G13: What is the users’ perceived Satisfaction of the Hand Tracking Application?

Participants were asked to evaluate their satisfaction with the Hand Tracking Application using a seven-point Likert scale. The results show generally high satisfaction, with most users expressing favorable opinions about the application's performance. The overall mean value was 5.39, suggesting that the majority of participants were pleased with their experience.

Table 16 Descriptive analysis with percentages of the items under the scale “Satisfaction” of the Hand Tracking Application

Responses	1	2	3	4	5	6	7	Mean Value
I am satisfied with it.	7%	0%	4%	7%	33%	22%	26%	5.3
I would recommend it to a friend	4%	4%	4%	4%	19%	41%	26%	5.56
It is fun to use.	4%	7%	0%	22%	15%	22%	30%	5.22
It works the way I want it to work.	4%	0%	4%	11%	33%	22%	26%	5.41
It is wonderful.	4%	4%	4%	4%	30%	30%	26%	5.44

The highest-rated item, with a mean of 5.56, was “I would recommend it to a friend,” indicating a strong likelihood of users suggesting the application to others. Additionally, “It is wonderful” received a mean of 5.44, reflecting that participants were highly satisfied with the overall quality of the application.

The item “It is fun to use” received a mean of 5.22, showing that while the application was appreciated for its utility, there was a slight difference in how engaging users found it.

9 References

EADTU (2010), Organising Lifelong Learning - A Report on University Strategies and Business Models for Lifelong Learning in Higher Education, Jørgen Bang - http://III-portal.eadtu.eu/images/files/Manual_Organising_EADTU%2024-09-2010.pdf

U.S. Air Force (1970). (Instructional System Development (ISD). AFM 50-2. Washington, DC: U.S. Government Printing Office.

Kirkpatrick (1959). Techniques for evaluating training programs. D.L Kirkpatrick, Journal of ASTD, 11 (1959), pp. 1–13

Lund, A. M. (2001). Measuring usability with the use questionnaire12. Usability interface, 8(2), 3-6.

10 Appendix I: Users final online survey for MOOC

10.1 Section 1: Users' opinion about their knowledge improvement supported by the STAYinBowling MOOC

- The following questions are meant to get the users' opinion about their knowledge improvement using the MOOC

Please rate your level of agreement with the following statements:

1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree

	1	2	3	4	5
The STAYinBowling MOOC increases my knowledge about bowling					
I catch the basic ideas of the knowledge taught about bowling					
I try to apply the knowledge about bowling					
I want to know more about the bowling					

10.2 Section 2: Users Evaluation of the MOOC

No.	Question	1	2	3	4	5
Segmenting & Sequence						
1.	Is the content segmented adequately (neither too wide nor too narrow)?	☐	☐	☐	☐	☐
2.	Is the sequencing well structured?	☐	☐	☐	☐	☐
Learning Content						
3.	The MOOC is suitable for me regarding my play in bowling	☐	☐	☐	☐	☐
4.	The MOOC is suitable for me regarding my prior knowledge on bowling	☐	☐	☐	☐	☐
5.	The MOOC is suitable for my learning goals	☐	☐	☐	☐	☐

6.	The learning objectives and topics are clearly defined	☐	☐	☐	☐	☐
7.	The multimedia material facilitated the study of the topics	☐	☐	☐	☐	☐
8.	The multimedia material was informative enough	☐	☐	☐	☐	☐
Design of text, graphics and videos						
9.	Texts were readable	☐	☐	☐	☐	☐
10.	Texts were understandable	☐	☐	☐	☐	☐
11.	Graphics were understandable	☐	☐	☐	☐	☐
12.	The quality of graphics was high	☐	☐	☐	☐	☐
13.	Graphics and video were readable	☐	☐	☐	☐	☐
14.	Videos were understandable	☐	☐	☐	☐	☐
15.	The quality of videos was high	☐	☐	☐	☐	☐
16.	Videos were easy to follow	☐	☐	☐	☐	☐
Impact of the course						
17.	This course will change my way of playing bowling	☐	☐	☐	☐	☐
18.	The degree of the change in playing bowling will be high due to this course	☐	☐	☐	☐	☐
19.	This course will improve my way of playing bowling	☐	☐	☐	☐	☐
20.	This course will change my way of playing bowling	☐	☐	☐	☐	☐

Overall opinion about the course						
21.	Comprehensive	☐	☐	☐	☐	☐
22.	Perceivable	☐	☐	☐	☐	☐
23.	Educational	☐	☐	☐	☐	☐
24.	Easy	☐	☐	☐	☐	☐
25.	Enjoyable	☐	☐	☐	☐	☐
26.	Interesting	☐	☐	☐	☐	☐
27.	Satisfactory	☐	☐	☐	☐	☐
28.	Well done	☐	☐	☐	☐	☐
29.	Scientific	☐	☐	☐	☐	☐
30.	Serious	☐	☐	☐	☐	☐
31.	Well prepared	☐	☐	☐	☐	☐
32.	Important	☐	☐	☐	☐	☐
33.	Innovative	☐	☐	☐	☐	☐
34.	Modern	☐	☐	☐	☐	☐
35.	Pedagogical	☐	☐	☐	☐	☐
36.	Well-targeted	☐	☐	☐	☐	☐
37.	Different	☐	☐	☐	☐	☐

11 Appendix II: Users final Online Survey for the IoT toolbox

11.1 Section 1: Users' evaluation of the IoT toolbox Usability

Please rate your level of agreement with the following statements about the usability of the IoT toolbox (both the step and hand tracking applications):*

Please choose the appropriate response for each item:

1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neutral, 5 = Somewhat Agree, 6 = Agree, 7 = Strongly Agree

No.	Question	1	2	3	4	5	6	7
1.	It helps me be more effective.	☐	☐	☐	☐	☐	☐	☐
2.	It helps me be more productive	☐	☐	☐	☐	☐	☐	☐
3.	It is useful.	☐	☐	☐	☐	☐	☐	☐
4.	It gives me more control over the activities in my life.	☐	☐	☐	☐	☐	☐	☐
5.	It makes the things I want to accomplish easier to get done	☐	☐	☐	☐	☐	☐	☐
6.	It is easy to use.	☐	☐	☐	☐	☐	☐	☐
7.	It is simple to use.	☐	☐	☐	☐	☐	☐	☐
8.	It is user friendly.	☐	☐	☐	☐	☐	☐	☐
9.	It requires the fewest steps possible to accomplish what I want to do with it.	☐	☐	☐	☐	☐	☐	☐
10.	I learned to use it quickly	☐	☐	☐	☐	☐	☐	☐
11.	I easily remember how to use it.	☐	☐	☐	☐	☐	☐	☐
12.	It is easy to learn to use it.	☐	☐	☐	☐	☐	☐	☐
13.	I am satisfied with it.	☐	☐	☐	☐	☐	☐	☐
14.	I would recommend it to a friend	☐	☐	☐	☐	☐	☐	☐
15.	It is fun to use.	☐	☐	☐	☐	☐	☐	☐
16.	It works the way I want it to work.	☐	☐	☐	☐	☐	☐	☐

17.	It is wonderful.	☐	☐	☐	☐	☐	☐	☐
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