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Development of a Microcontroller-Based Melinjo Tool as a Medium for Football Goalkeeper Reflex Training

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Abstract
This study aims to develop a melinjo tool based on the ESP32 microcontroller as a medium for training reflexes for soccer goalkeepers and determine its feasibility based on expert validity and user responses. The research method uses the Sugiyono Research and Development (R&D) model with seven stages: identification of potential and problems, information collection, product design, expert validation, product revision, product trial, and final product. Validation was carried out by material experts and media experts using a questionnaire instrument with a scale of 1–5. The trial involved 19 respondents (3 on a small scale and 16 on a large scale) from six affiliated soccer schools in Kediri Regency. The results of the validation by material experts obtained a percentage of 96% (very feasible) and by media experts, 81% (very feasible). The small-scale trial resulted in a feasibility percentage of 72% (feasible), and the large-scale trial increased to 91% (very feasible). This increase indicates that the product revision has succeeded in significantly improving the quality and user acceptance. It is concluded that the melinjo tool is feasible and very feasible to be used as a training aid to improve the reflex abilities of soccer goalkeepers.

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1. INTRODUCTION

Football is the world's most popular sport, played by two teams of 11 players each, with the primary objective being to score as many goals as possible against the opposing team (Luxbacher, 2023). In Indonesia, football is not only a form of entertainment but also plays a vital role in character building, improving health, and strengthening national pride. As part of the national sports system, the development of competitive sports is emphasized in Law Number 11 of 2022, which emphasizes the importance of systematic, tiered development supported by sports science and technology.

In soccer, the goalkeeper plays a highly strategic role as the team's last line of defense. Optimal goalkeeper performance is considered to make the team difficult to defeat, including in organizing attacks through build-up from the back. Reflexivity is one of the key physical elements that goalkeepers must possess, namely the ability to respond to visual stimuli quickly and accurately with appropriate motor movements (Rajak & Anirban Mishra, 2025). Good reflex speed allows goalkeepers to deflect or catch the ball from close-range shots that come unexpectedly.

Technology-based aids in sports have been shown to provide significant advantages in training effectiveness. Technology can be defined as the use of tools or devices during competition designed to achieve specific values or functions in the field of sport (Indik Syahrabanu, 2023). Several previous studies have confirmed the effectiveness of electronic training tools for goalkeepers. Mohamad Bustan David et al. (2024) developed

an Android-based tool with a validation rate of 97–98% and a field feasibility of 96%. Tarigan and Siregar (2021) reported product validation of 95%, with 100% of athletes experiencing increased motivation. Malik et al. (2024) developed a reflexology tool with a feasibility rating of 94% from material experts and 92% from media experts. Pratama (2020) recorded a feasibility rating of 75–83% from experts, with a positive field response of 81–90%.

However, goalkeeper reflex training at the Tamtama FC Kediri Regency soccer school is still conducted conventionally, involving manual catching of flat, medium, and low balls. The lack of electronic aids hinders the optimization of reflex training in a measurable and varied manner. Surveys and interviews with coaches revealed no specific electronic devices designed to improve goalkeeper reflexes at the soccer schools studied.

Based on these problems, this study aims to develop a melinjo device based on an ESP32 microcontroller as a medium for reflex training for soccer goalkeepers and determine its feasibility. The name melinjo was chosen because the melinjo plant has red, yellow, and green seeds, corresponding to the color of the lights used in this device. This device is designed to be portable with five levels of random light speed, allowing coaches to vary the training load according to the abilities of each goalkeeper.

2. RESEARCH METHODS

This study uses the Research and Development (R&D) method, which is a series of research actions starting from Research activities to obtain information about problems and user needs, followed by Development to create tools as solutions (Sugiyono, 2025). The development model applied refers to the Bord & Gall R&D steps adapted by Sugiyono (2025) in seven operational stages, namely identification of potential problems, information collection, product design, expert validation, product revision, product trials, and final products.

The product developed is a melinjo tool consisting of three main units of Box Master (ESP32U-Devkit 4 Wroom microcontroller as the main controller), Box Slave Lamp (ESP32-S3 microcontroller with three high-power LEDs in red, yellow, green), and Box Slave Sensor (ESP32-C3 microcontroller with RCWL-1601 ultrasonic sensor). The three units communicate wirelessly via the ESP-NOW protocol. The tool uses lightweight atomic plastic material, is supported by a tripod, and is operated portably using 18650 batteries connected in parallel.

The research instrument was a closed questionnaire with 15 statements covering three assessment aspects: the appearance and design of the tool (items 1–5), the operational safety of the tool (items 6–10), and the functional feasibility of the tool (items 11–15). The assessment scale used a 5-point Likert scale: 5 = Very Feasible, 4 = Feasible, 3 = Quite Feasible, 2 = Not Feasible, 1 = Very Not Feasible (Ernawati & Sukardiyono, 2017). Data analysis used a percentage technique based on Arikunto's (2021) formula: $P = (F/N) \times 100\%$, where P is the percentage score, F is the total score given, and N is the maximum total score. The feasibility categories were determined as follows: 81–100% = Very Feasible, 61–80% = Feasible, 41–60% = Quite Feasible, 21–40% = Not Feasible, and <21% = Very Not Feasible.

Product validation was conducted by two expert validators, namely a material expert (Dwi Kurnia Shandy, M.Pd., a lecturer at the National Sports and Health Education (Penjaskesrek) PGRI Kediri with expertise in football coaching) and a media expert (Rendhitya Prima Putra, M.Pd., a lecturer at the National Sports and Health Education (Penjaskesrek) PGRI Kediri with experience in the media field). The product trial was conducted in two stages: a small-scale trial involving 3 respondents (2 goalkeepers and 1

coach) from SSB Tamtama FC on June 9, 2026, and a large-scale trial involving 16 respondents (12 goalkeepers and 4 coaches) from four affiliated SSBs in Kediri Regency (SSB SKB, SSB Putra Sakanira, SSB Arsena, SSB Angsa Putih) on June 11–18, 2026. The selection of trial subjects used a purposive sampling technique (Sugiyono, 2025).

3. RESULTS AND DISCUSSION

Product Description of Melinjo Tools

The final product of the melinjo tool is a microcontroller-based goalkeeper reflex training device designed to provide visual stimuli in the form of randomly flashing lights. Goalkeepers are trained to react as quickly as possible to touching the flashing lights, mimicking real-life match conditions where goalkeepers must respond to balls coming from unexpected directions. The tool has five levels of light flashing speed, where the higher the selected level, the faster the lights flash randomly and the higher the demand for the goalkeeper's reflex speed. The brightness of the lights can be adjusted using a potentiometer, while communication between units uses the wireless ESP-NOW protocol, thus reducing the risk of damage and the complexity of cable installation when used in the field.

Expert Validation Results

Product validation was conducted by two experts before the product was field tested. The material expert validation covered four assessment aspects: the tool's material, the physical aspect of the tool, the design aspect of the tool, and the usability aspect of the tool. The media expert validation covered three aspects: the physical aspect of the tool, the design aspect of the tool, and the usability aspect of the tool. The complete results of the two expert validations are presented in Table 1.

Table 1. Summary of Expert Validation Results

Validator	Rated aspect	Acquisition Score	Shoes Max.	Percentage
Material Expert (Dwi Kurnia Shandy, M.Pd.)	Tool Material	18	20	90%
	Physical Tools	25	25	100%
	Tool Design	14	15	93%
	Use of Tools	15	15	100%
Total Subject Matter Experts		**72**	**75**	**96%**
Media Expert (Rendhitya Prima Putra, M.Pd.)	Physical Tools	19	25	76%
	Tool Design	24	25	96%
	Use of Tools	14	20	70%
Total Media Members		**57**	**70**	**81%**

Based on Table 1, the validation by the material expert obtained a total score of 72 out of a maximum score of 75 with a percentage of 96%, falling into the very suitable category. The physical aspects of the tool and the aspect of use of the tool received a perfect score of 100%, reflecting that in terms of material comfort, portability, and ease of operation, the melinjo tool is fully suitable for goalkeeper training needs. Notes for improvement from the material expert include the placement of lights, which should be adjusted to the user's age group, considering the goal sizes for different age groups.

Media expert validation obtained a total score of 57 out of a maximum score of 70 with a percentage of 81%, also in the very appropriate category. The design aspect of the tool received the highest percentage (96%), indicating that the selection of red-yellow-green light colors, component layout, and design details were considered appropriate. The physical aspect of the tool received the lowest score (76%), with notes on improvements in

battery life, the use of a tripod that needs to be maximized, and the sensitivity of the ultrasonic sensor on the slave sensor box that is still considered to need refinement.

These validation results align with research by Mohamad Bustan David et al. (2024), who obtained validation scores of 97% from media experts and 98% from coaching experts, and Malik et al. (2024), who obtained 94% from media experts and 92% from coaching experts. The consistency of these results indicates that the light sensor and microcontroller-based tool generally received a very positive validation response from experts in the fields of coaching and sports media.

Product Trial Results

Following expert validation and product revision, trials were conducted in two stages. A small-scale trial was conducted on the Tamtama FC SSB field, involving three respondents (one coach and two goalkeepers). A large-scale trial was conducted at four affiliated SSBs in Kediri Regency, involving 16 respondents (four coaches and 12 goalkeepers). Complete data on the trial results per individual are presented in Table 2.

Table 2. Results of Small-Scale and Large-Scale Trials

No	Number	Status	SSB	Score	Shoes Max.	Percentage & Category
Small Scale Trial						
1	Sumarji	Coach	FC Private	55	75	73% – Decent
2	Alfaro	Goalkeeper	FC Private	52	75	69% – Eligible
3	Azril	Goalkeeper	FC Private	55	75	73% – Decent
Small Scale Total	**162 / 225**					**72% – Decent**
Large-Scale Trial						
1	Anta	Coach	SKB	49	75	65% Eligible
2	Triyas	Coach	Don't refuse.	72	75	96%–Very Decent
3	Sunarko	Coach	Arsenic	65	75	86%–Very Decent
4	Rowi	Coach	AWhite swan	68	75	90% Very Decent
5	David	Goalkeeper	SKB	70	75	93%–Very Decent
6	Reza	Goalkeeper	SKB	69	75	92%–Very Decent
7	Putra	Goalkeeper	Don't refuse.	74	75	98%–Very Decent
8	Ibra	Goalkeeper	Srefuse	75	75	100%-Very Worthy
9	Abqori	Goalkeeper	Srefuse	75	75	100%–Very Worthy
10	Devano	Goalkeeper	Don't refuse.	74	75	98%–Very Decent
11	Aldo	Goalkeeper	Don't refuse.	72	75	96%–Very Decent
12	Aldi	Goalkeeper	Arsena	62	75	82%–Very Decent

13	Danish	Goalkeeper	White swan	71	75	94%–Very Decent
14	Akbar	Goalkeeper	White Swan	65	75	86%–Very Decent
15	Rafa	Goalkeeper	White swan	68	75	90%–Very Decent
16	Devano	Goalkeeper	White Swan	72	75	96%–Very Decent
Large Scale Total	**1.101 / 1.200**					**91% – Very Decent**

Based on Table 2, there was a significant increase in the feasibility percentage from the small-scale trial (72%) to the large-scale trial (91%), amounting to 19 percentage points. This increase indicates the success of the product revision phase conducted after the small-scale trial. Improvements included adjusting the lighting placement, strengthening the tripod construction, and increasing the sensitivity of the ultrasonic sensor on the slave sensor box, based on respondent input and expert recommendations.

In a large-scale trial, 15 out of 16 respondents (93.75%) gave the app a very good rating. Two goalkeepers (Ibra and Abqori) gave it a perfect 100% rating, while one coach (Anta) gave it a 65% rating. This difference in ratings between respondents is understandable, given their varying backgrounds, experiences, and expectations. Overall, the average rating of 91% indicates excellent acceptance by users in the field.

These trial results are consistent with previous research in the same field. Pratama (2020) reported a 90% positive response in a large group for a goalkeeper reaction light sensor device. Tarigan and Siregar (2021) obtained a 95% feasibility percentage from expert assessments, and 100% of athletes felt increased training motivation. Sagala and Sitepu (2022) recorded a 95% feasibility percentage in a large group test for a reaction speed training device. This comparison indicates that the melinjo device has a competitive feasibility level compared to similar products previously developed.

Overall Eligibility Recapitulation

Table 3. Recapitulation of the Percentage of Eligibility for All Testing Stages

Testing Level	Respondent	Score Obtained / Max.	Percentage	Category
Subject Matter Expert Validation	1 member	72 / 75	96%	Very Worthy
Media Expert Validation	1 member	57 / 70	81%	Very Worthy
Small Scale Trial	3 respondents	162 / 225	72%	Eligible
Large-Scale Trial	16 respondents	1.101 / 1.200	91%	Very Worthy

Table 3 shows that all three validation and trial stages consistently placed the melinjo tool in the feasible to highly feasible category. Subject matter expert validation achieved the highest percentage (96%), followed by large-scale trials (91%), media expert validation (81%), and small-scale trials (72%). This pattern reflects a healthy development cycle: expert validation provides strong conceptual confirmation, while scaling up from small to large scale demonstrates the effectiveness of the product revision and refinement process.

Singchainara et al. (2022) reported a content validity of 89% and a reliability of 0.88 for the goalkeeper reaction time test (RTTGI) in the Thailand U-League, while research by Rajak and Anirban Mishra (2025) confirmed that wireless light sensor-based technology such as the Fitlight system has been shown to effectively improve reaction speed and cognitive abilities in soccer players. The melinjo tool adopts similar principles with the addition of multi-speed features and a more affordable, portable design suitable for soccer schools in Indonesia.

4. CONCLUSION

Based on the research results and discussion, the following conclusions can be drawn. First, the ESP32 microcontroller-based melinjo device was successfully developed through a systematic R&D procedure, resulting in a product in the form of three integrated units (Master Box, Lamp Slave Box, Sensor Slave Box) with five levels of random light speed in three colors (red, yellow, green).

Second, the level of elinjo tool feasibility based on expert validity showed very feasible results, namely 96% from material experts and 81% from media experts. Third, user responses through field trials showed a feasible category (72%) on a small scale and increased to very feasible (91%) on a large scale, with an increase of 19 percentage points reflecting the success of the product revision process. Fourth, overall, the melinjo tool was declared feasible and very feasible to be used as a medium to help coaches in improving the reflex abilities of soccer goalkeepers from the aspects of material, physical, design, and ease of use.

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