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AUGMENTED REALITY IN CULINARY ARTS EDUCATION: A SYSTEMATIC REVIEW OF LEARNING EXPERIENCES, PRACTICAL SKILLS, AND IMPLEMENTATION CHALLENGES

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Abstract

Augmented Reality (AR) is increasingly used to present food-related information and support selected learning tasks and preparations in culinary contexts. This study systematically reviews the applications of Augmented Reality (AR) relevant to culinary arts education, focusing on learning experiences, practical skills development, and implementation challenges. This review covers scientific publications for the period 2017–2026 following the PRISMA 2020 guidelines. The literature search was conducted through five platforms, namely Scopus, ScienceDirect, Google Scholar, IEEE Xplore, and GARUDA. The last search was conducted on October 25, 2026. A total of 15 articles that met the inclusion criteria were analyzed through thematic synthesis based on three research focuses, namely learning experiences, practical skills, and the challenges of implementing AR in culinary arts education. The literature suggests that AR can support three-dimensional visualization, ingredient information, recipes, understanding of cutting techniques and food portions. Nevertheless, the strength of the evidence varies according to the context and design of the study: expert validation, self-reported understanding, prototype usability, and measured task performance are not equivalent outcomes. Current evidence does not show a broad improvement in the psychomotor competencies of culinary students. Implementation is also shaped by the absence of tactile physical feedback, limitations of interfaces and devices, and the demands of an active kitchen environment. AR is therefore best considered a complementary resource for pre-practicum preparation and carefully selected task support. Postpracticum reflection may be a useful pedagogical application, but its effectiveness requires hands-on evaluation.

Keywords: Augmented Reality; Culinary Arts Education; Learning Experience; Practical Skills; Systematic Literature Review

INTRODUCTION

Culinary Arts is one of the important courses in the Culinary Education Study Program because it plays a role in developing students' creativity and connecting theoretical understanding with practical activities [1]. To support the learning process, media that is able to present the material in an interesting way and in accordance with learning needs is needed. The development of *flipbook* media on sus dough materials shows one of the efforts to provide teaching materials that support the culinary learning process [2]. Although written recipes, demonstrations, and video tutorials are still used in learning activities, these media have limitations in providing direct interaction when students are practicing. The use of screen devices, for example, can interfere with activities when the user's hands are busy or dirty during the cooking process [11]. This condition shows the need for alternative learning media that is

able to present information visually without hindering activities in the work area, one of which is through the application of *Augmented Reality* (AR).

Although the application of AR to culinary arts materials has included various learning activities and the presentation of dishes based on aesthetic value (food *plating*). Studies on the relationship between visualization-based learning experiences and the achievement of practical skills have not been comprehensively synthesized. This gap demonstrates the need for a systematic review to identify the contribution of AR to the learning experience as well as the development of practical skills in culinary arts education. The novelty of this study lies in the systematic synthesis of AR-supported visual and cognitive learning outcomes and the available evidence on their contribution, as well as identifying various constraints that may affect the application of conceptual understanding into culinary practice skills. This study addresses the following research questions: (1) How does AR support learning experiences in culinary arts education? (2) What evidence is available regarding the contribution of AR to the development of practical skills in culinary arts education? and (3) What technological, ergonomic, and pedagogical challenges affect the implementation of AR in culinary practical learning environments?

LITERATURE REVIEW

The use of *Augmented Reality* (AR) in culinary arts education is beginning to be directed to help students understand the material through visualization and digital interaction. This technology allows the shapes and characteristics of food ingredients to be displayed in three dimensions, so that it can help the understanding of processing techniques, including plant-based cutting techniques [7]. In addition to visualization, AR was also developed as an interactive cooking guide that presents instructions in stages during the food processing process [9]. Its application in the practical environment is also developed through *spatial AR,* which allows instructions to be displayed directly in the work area and evaluated based on the user's usability and workload [11]. These three approaches show that AR can support the delivery of materials, understanding of procedures, and interactions during culinary practice activities.

RESEARCH METHODS

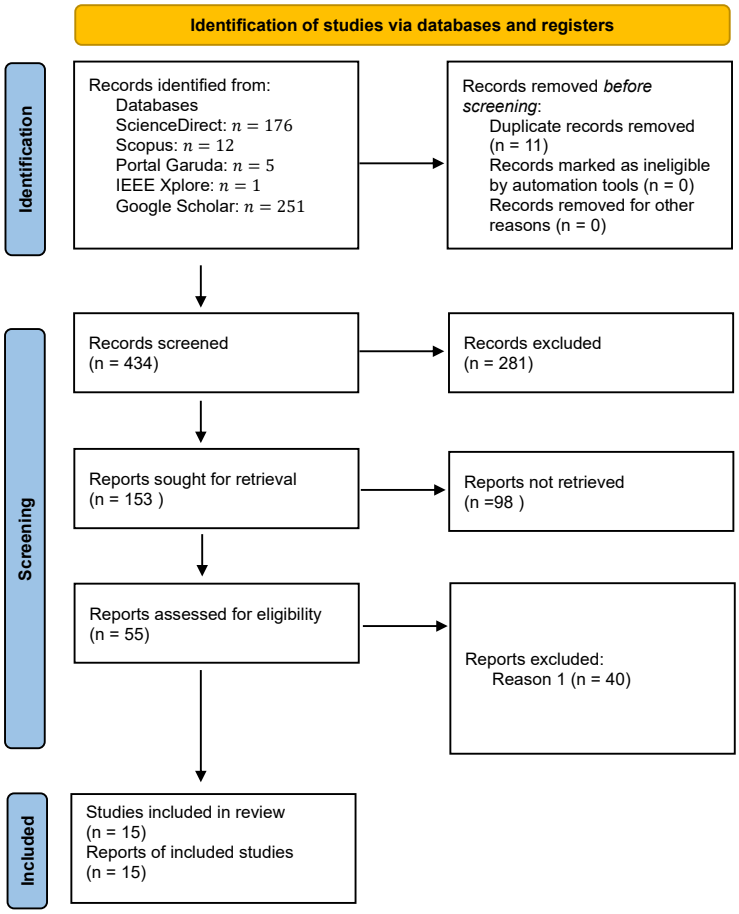
Research Design

This study uses *the Systematic Literature Review* (SLR) method to examine the application of *Augmented Reality* (AR) in culinary arts education. This study follows the guidelines of PRISMA 2020 [15] and focuses on three aspects, namely learning experience, practical skill development, and challenges of applying AR.

PRISMA Method

The literature search was conducted through Scopus, ScienceDirect, IEEE Xplore, Garuda Portal, and Google Scholar, with a publication range of 2017-2026. The keywords used were related to *Augmented Reality*, culinary arts education, culinary learning, and practical skills. Articles were selected based on their suitability with the topic and research question. The article selection process is presented in Figure 1.

Figure 1. PRISMA Method.



The selection process was carried out through the examination of titles, abstracts, and complete texts by one reviewer. Of the 445 articles found, 11 duplicate articles were removed and 281 articles were removed at the screening stage. Furthermore, 98 of the 153 articles searched were not successful. A total of 55 articles were fully examined and 40 articles were issued, resulting in 15 articles being obtained for analysis. The data collected included authors, year of publication, research methods, application of AR, and key findings. The quality of the articles was assessed based on the research design, clarity of objectives, accuracy of methods, and relevance of results. Furthermore, data were analyzed using thematic synthesis based on three research focuses, namely learning experience, practical skills, and challenges of applying AR.

RESULTS AND DISCUSSION

Characteristics of Selected Studies

This review analyzed 15 selected publications related to learning experiences, practical skills, and AR implementation challenges. The study methods were diverse, ranging from expert tests, development research, experiments, prototype tests, to literature reviews. All findings were analyzed in a related manner without combining statistical effects (*pooled effects*). A complete summary of the 15 articles can be seen in Table 1.

Table 1. Overview of Selected Studies on Augmented Reality in Culinary Arts Education

Author/ Year	Context and Methods	AR Applications	Key Findings	Limitations
Majil et al. (2022)	prototype development and usability tests involving 20 participants to follow AR guidance in the practice of making white cakes.	The Magic Leap One *headset-based system* recognizes ingredients, displays step-by-step guide videos, and is controlled through eight types of hand movements.	All participants managed to make the cake without fatal mistakes and expressed complete satisfaction, with 19 out of 20 participants willing to recommend the system.	Gesture sensors are sometimes too sensitive, as well as *headsets* heat up easily and are less user-friendly to glasses.
Despriaryandi & Asriningtias (2023)	AR learning media, using the SDLC method	marker-based Android application that displays interactive 3D visualization of objects, tools, and culinary ingredients	display 3D objects and support visualization of Culinary learning materials.	It has not measured the improvement of students' understanding and practical skills directly.
Mohamad et al. (2026)	Quantitative research using *the Fuzzy Delphi method*	AR-based learning framework designed for food preparation and production activities	The 14 items in the two main constructs, namely learning strategies and teaching activities, managed to obtain a consensus of 100% agreement.	has not yet tested its application to students' practical skills in the kitchen.
Jiménez Landa et al. (2026)	Action research on 17 lecturers and 113 students	CulinaryVision smartphone *app* that displays 3D models of vegetables interactively	As many as 78.8% of students feel that the accuracy of the experimental group quiz is superior	Evaluation still focuses on perception and cognitive understanding.
Ghasemi et al. (2024)	An experimental study on 22 participants comparing *spatial AR* (sAR) and video tutorials in a *playdough cooking simulation*	The sAR Kitchen *system* that projects step-by-step instructions directly onto the kitchen table and is controlled through hand gestures	The sAR system improves usability score and lowers the workload compared to video	Testing only uses *playdough simulations*
Dewi et al. (2025)	ADDIE-based development involving five expert validators and 17 students	Android-based AR learning media	The media obtained a validity value of 0.93 and practicality of 80.53%	The measurement of learning outcomes only used 15 multiple-choice questions.
Rollo et al. (2017)	A randomized experimental study involving 90 participants in users	ServAR tablet app that projects visual guidance on food portion size.	Portion estimation accuracy is superior to other groups	only focusing on the accuracy of measuring food portions

Author/ Year	Context and Methods	AR Applications	Key Findings	Limitations
	of *the ServAR* application.			
Mellos & Probst (2022)	AR apps, online tools, and infographics.	Smartphone AR app based on QR codes and markers	The AR group recorded the highest increase in estimates (12.2%) compared to online tools (11.6%) and infographics (−1.7%)	Testing using images only
Jou, Chiang, & Hao (2026)	Mixed-methods sequential explanatory *study* on culinary students	An Immersive Experiential-Flipped AR *(IEFT-AR) approach that combines* flipped learning, experiential learning, *and* knife skills procedural training.	AR immersion successfully strengthens confidence	AR interventions did not directly result in an increase in physical skills scores
Bui & Rodriguez Lovell (2024)	AR app development	Banh Chung AR *App*	AR design principles for the transmission of culinary culture that includes the visualization of cultural heritage	Focus on cultural preservation through AR interactive games
İntepe & Demirgül (2024)	Utilization of AR, VR, and MR in culinary science.	Sensory perception of taste, marketing, and culinary practice training.	AR and VR technology in support of the gastronomic field	combines AR, VR, and MR so that AR's specific contribution to culinary learning is difficult to separate.
Fitriyana & Nurhadi (2025).	Conceptual study of learning based on the integration *of Cognitive Theory of Multimedia Learning*	ARECL *conceptual model*	the potential of AR in supporting visual-spatial abilities	The proposed learning model has not been empirically tested on students
Azizah et al. (2026)	ADDIE model involving 34 students	AR integrated printed *flashcard* media	helps to overcome students' passivity in observing the 3D structure of vegetable pieces in a precise and aesthetic manner.	It has not been measured to improve the motor skills of cutting materials directly.
Brown et al. (2019)	Evaluation study of the effectiveness and usability of AR-	ZapWorks-based *ServARpreg*	ease of use, as well as increased accuracy	Testing limited to visual portion

Author/ Year	Context and Methods	AR Applications	Key Findings	Limitations
	based educational tools	*smartphone application*		measurement accuracy
Saha et al. (2022).	AR-based pilot *study*	AR-based PortionSize smartphone app	The app's viability is rated good	visual AR has accuracy issues when recognizing food

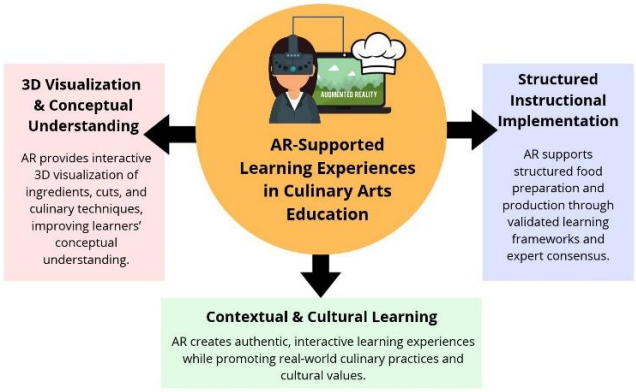
Source: Author's synthesis

Augmented Reality to Enhance the Culinary Learning Experience

The application *of Augmented Reality* (AR) in culinary arts learning provides opportunities for students to understand the material through more concrete and interactive representations of objects. One of the applications can be seen in the development of an Android-based AR application for students of the Culinary Arts Vocational School that allows interaction with three-dimensional objects in *real-time* [5]. This development resulted in a learning application aimed at providing an alternative to presenting culinary materials that are more interesting. The need for visualization is increasingly seen in food cut materials, because conventional learning media have not been able to adequately describe the shape and technique of cuts. To overcome these limitations, AR-integrated *flashcard* media was developed by combining printed cards and three-dimensional object visualization. The test results showed a material feasibility of 91% and a media feasibility of 97%, both of which are in the very feasible category [16]. These findings show that AR can clarify the visual representation of culinary materials, especially in objects that require more detailed observation of shapes and characteristics. Thus, AR's contribution lies not only in the use of digital technology, but also in the way culinary materials are presented to make them easier to observe by students.

The AR learning media experience can then be developed into more contextual learning through the interaction between virtual objects and the real environment. This can be seen in the development of *Banh Chung AR,* which allows users to place virtual objects in the form of bases, pots, banana leaves, and rice on various surfaces in the space where they live. Through this mechanism, daily spaces can be changed to adjust the placement of objects to the conditions of their respective spaces, so that the interaction experience does not only depend on digital objects, but also on the user's physical environment [6]. In the context of culinary vocational learning, this kind of experience requires the support of a directed learning strategy. This is strengthened by the validation of the AR integrated pedagogical framework involving 11 experts and resulting in a 100% consensus on all items in two constructs, namely learning strategies and teaching activities. Components that received high priority included AR-assisted teacher demonstrations, problem-based learning, procedure sequence guides, recipe-based practice activities, and hands-on practice with teacher guidance [3]. Overall, the findings suggest that AR has the potential to enrich the culinary arts learning experience when its visualization and interactivity are integrated with the learning context and teacher guidance.

Figure 2. Conceptual Synthesis of AR-Enhanced Culinary Learning Experiences

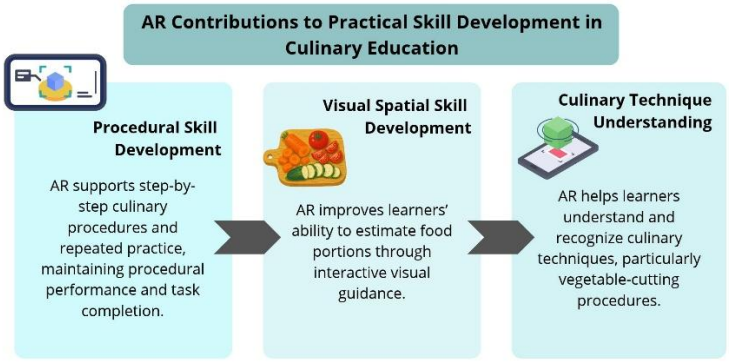


Augmented Reality to Support the Development of Culinary Practice Skills

The use of Augmented Reality (AR) in the development of culinary arts practice skills can be seen from the ability to provide procedural guidance, clarify processing techniques, and help learners follow the work stages. One of the applications is demonstrated through the AREasyCooking application which integrates the introduction of food ingredients with a gradual video guide of the recipe. The application is also designed using voice and eye control so that the user can still follow the instructions when both hands are used for cooking [21]. In the context of culinary arts, the integration of AR also needs to be accompanied by a directed learning strategy. The pedagogical framework developed for food preparation and production activities obtained a 100% consensus from experts on all learning activities, including lecturer demonstrations, recipe-based practices, procedural guides, and hands-on exercises with teacher assistance [3]. A more specific application is seen in Continental Food learning, when AR is used to simulate the structure of ingredients, food arrangement, and the arrangement of dishes on plates. Testing of 17 students showed an increase in average learning outcomes from 69.52 to 85 after the use of AR media, with statistical test results showing significant differences [4]. The findings show that AR can help clarify the stages and representations of the culinary process before students carry out practical activities directly.

AR's support for practical skills was also seen in learning cutting techniques and food portion estimation. The use of the CulinaryVision application that featured three-dimensional models of vegetables helped students understand the shape of regular and irregular cuts, with 78.8% of the students of the experimental group stating that the application helped improve their understanding of professional cutting techniques [7]. However, the results were more indicative of students' understanding and perception than the improvement of their motor skills directly. In the aspect of portion measurement, the ServAR application was able to help users estimate the serving through virtual portion visualization on a plate, with 90.7% estimating to be within the error range ±50% [10]. Another study also reported a 12.2% increase in estimated results in the AR user group, although the study was conducted on nutrition students using food images rather than through direct food processing practices [12]. Overall, the results showed that AR has the potential to support procedural understanding, technique recognition, and visual-spatial skills in culinary activities. However, evidence on improving the accuracy of hand movements, mastery of kitchen utensils, and the quality of food processing results directly still needs to be developed through further research.

Figure 3. Synthesis of Empirical Findings on AR Supported Culinary Skill Development.

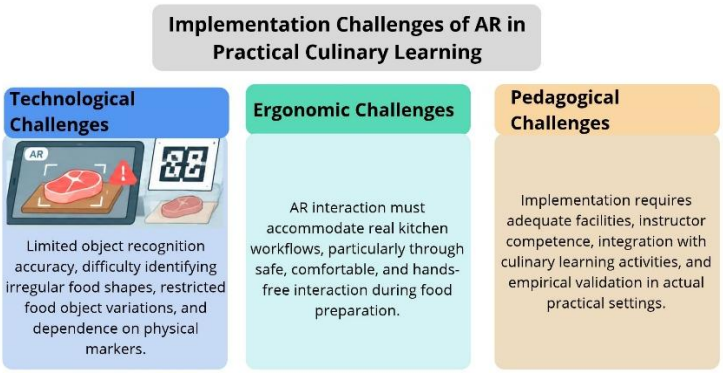


Implementation Challenges and Pedagogical Positions Augmented Reality

The challenges of applying Augmented Reality (AR) in the learning environment of culinary arts practice include technological, ergonomic, and methodological aspects. In the technological aspect, research on the application of food portion estimation shows that the recognition of food with irregular shapes is still an obstacle in producing accurate estimates, including the potential for errors in estimating energy content [18]. Similar limitations can be seen in research on the use of AR for learning the concept of food portions. Although this technology is able to increase the accuracy of portion estimation by 12.2%, its implementation still faces limitations in food object variation, dependence on physical markers (fiducial markers), and higher absolute error rates compared to online tools [12]. Meanwhile, from a methodological perspective, studies on the application of immersive technology in the field of gastronomy still discuss AR and VR simultaneously and mention their relationship with MR. This highlights the need for more specific research to examine the contribution of AR to culinary learning through experimental testing in hands-on activities [13].

Efforts to overcome these various obstacles require designing interactions that are appropriate to working conditions in the kitchen and an integrated pedagogical approach. One approach is demonstrated through the Spatial Augmented Reality (sAR Kitchen) system, which projects instructions directly on a workstation and allows users to operate the guide through touchless hand movements. The results of the evaluation show that the system has a higher usability score and a lower perceived workload than video tutorials, although the test has not yet involved direct food processing activities [11]. From the pedagogical side, the Augmented Reality-Based Experiential Culinary Learning (ARECL) model proposes four stages of learning, namely Visual Immersion, Guided Interaction, Applied Simulation, and Reflective Evaluation. This framework integrates three-dimensional visualization with guided interaction, procedural simulation, and learning evaluation. However, its implementation still requires the support of educational facilities, the readiness of teacher competencies, and empirical testing to determine its effectiveness in culinary practice activities [14].

Figure 4. Dimensions of AR Implementation Challenges in Practical Culinary Education.



CONCLUSION

Based on a synthesis of fifteen selected publications, the study concludes that Augmented Reality (AR) offers the potential to support learning experiences and selected practical tasks in culinary education, although evidence of its contribution to the development of measurable practical skills is still limited. The implementation of AR also involves technological, ergonomic, and pedagogical challenges. The main conclusions are as follows.

1. AR can support the learning experience through three-dimensional visualization, presentation of ingredient and recipe information, and interactive procedural guides. These functions can help learners understand culinary content and preparation procedures visually and contextually.
2. AR can support understanding of cutting techniques, selected cooking procedures, and estimated food portions. Nevertheless, direct evidence of improvements in practical culinary skills is still limited because most studies measure content comprehension, user perception, usability, or task completion, rather than psychomotor competencies through objective performance assessments.
3. The implementation of AR faces challenges related to object recognition, interaction sensitivity, device comfort, and compatibility with practical kitchen activities. Therefore, AR should be used as a complementary learning resource integrated with teacher demonstrations, instructor guidance, and hands-on practice.

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