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AUGMENTED REALITY LABELS FOR TEACHING FACTORY PRODUCT PRESENTATION IN A VOCATIONAL HIGH SCHOOL (MULTIMEDIA PROGRAM)

Herman Thuan To Saurik[1], Kelvin[2], Sigit Firdaus Prayogi[3], Taufikur Rahman[4]
[1,2,3]Institut Sains dan Teknologi Terpadu Surabaya
[4]SMKN 1 Sumenep
E-mail: thuan@stts.edu[1*], kelvin@stts.edu[2], sigit@stts.edu[3], taufik@smkn1.edu[4]

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Abstract

This study implements the application of Augmented Reality (AR) on labels or packaging of Teaching Factory (TEFA) SMK Multimedia Program products. An R&D design with a Design Thinking framework (Empathize–Test) was used as a user-centered solution. The prototype was developed using Unity–Vuforia and tested on 55 respondents (50 students and 5 teachers) through questionnaires and observations. Descriptive results show strong support for the feasibility of AR as a presentation medium and practical teaching material. The packaging design results before AR were rated positively with a rating of Good–Very Good at 74.6%. The most appreciated AR element was 3D animation at 85.5%. From a promotional perspective, AR results were perceived as effective–very effective at 81.8%. In the field of vocational education, the description of industrial workflows was considered very comprehensive by the majority at 83.6%, with an adoption interest of 85.5%. The main challenges lie in the application of usability and technical complexity (rated as difficult and very difficult by 60.0%), so improvements to the UI/UX, optimization of 3D asset quality, and the addition of CTA features (buy/location/QR links) are recommended. These findings indicate that the application of AR label technology increases appeal, enriches product understanding, and is relevant as a TEFA project module, while also opening up room for improvement in usability and content pipeline to ensure the sustainability of implementation in vocational learning at SMK Multimedia Program.

Keywords: Teaching Factory, Augmented Reality, Digital Marketing, Design Thinking.

INTRODUCTION

The development of digital marketing in the era of Industry 4.0 has changed the paradigm of communication between producers and consumers. Marketing strategies are no longer solely focused on disseminating product information, but rather on creating interactive and immersive experiences that build emotional closeness and trust in the brand. This transformation requires businesses, including vocational education institutions, to adopt creative technology-based approaches in order to compete in the dynamic digital space. In the context of vocational education, the ability to manage digital promotion has become an important part of students' technological literacy and entrepreneurship skills, especially in the Teaching Factory (TEFA) model, which combines learning activities with real production (Padmasari, Sutianah, & Prana, 2024). The TEFA model enables students to produce market-ready products through a process that resembles the actual industry. However, the main challenge in implementing TEFA is how to market students' work in an attractive and competitive manner in the digital market. SMKN 1 Sumenep, for example, has produced various TEFA products in local packaging, such as snacks, roasted peanuts, anchovies, and potato chips. Despite their high economic potential and cultural value, promotion of these products is still limited to printed catalogs or static social media posts, which fail to provide an attractive visual experience for potential consumers (Yang & Lin, 2024). This problem calls for promotional innovations that can integrate educational, interactive, and aesthetic aspects in a unified manner. Augmented Reality (AR) technology offers innovative solutions in combining the real world and virtual objects in real time, providing an interactive experience that enriches users' perception of products (Söderström, 2024). International evidence shows that AR can increase learning interest, user enthusiasm, and communication effectiveness in the context of applied education while overcoming limitations in space, equipment, and practice costs (Soni & Tandan, 2024; Vashisht, 2024; Chiang, Shang, & Qiao, 2022). Research in various educational domains, including language and science, also shows that

AR implementation can increase participant engagement, conceptual understanding, and learning motivation (Nan, 2025; Singh, Garg, & Soni, 2024). In the field of vocational arts, the use of AR-based learning modules has been proven effective in enhancing students' creativity and learning outcomes (Yekti, Rahayuningtyas, & Sayekti, 2024). Meanwhile, in the context of public promotion, tourism AR has demonstrated technical feasibility and high user acceptance, providing a strong reference for the promotion of TEFA products that rely on the visualization of local attractions (Ranawijaya, Iryanti, & Ferdinanda, 2020). Even in tourism education, mobile AR as an interactive learning medium has been proven to increase motivation, engagement, and conceptual understanding, while also leveraging the adoption of everyday devices (Puja, Winatha, & Aryasih, 2025).

To ensure that AR-based innovations in TEFA are truly user-centered and aligned with market needs, the Design Thinking framework is used as a solution development approach. This model (Empathize, Define, Ideate, Prototype, Test) encourages a creative yet analytical process in designing interactive promotional media. Findings in technical education show an increase in empathy, problem-solving, and more user-oriented prototype outputs (Turcios-Esquivel, Avilés-Rabanales, & Hernández-Rodriguez, 2024). In the practice of AR-assisted TEFA product rebranding assistance, teachers experienced strengthened TPACK competencies and students increased their participation in digital content design and creative promotion strategies (Padmasari et al., 2024). Therefore, this study focuses on developing interactive Augmented Reality-based promotional media for TEFA products at SMKN 1 Sumenep, with the main objectives of: (1) increasing consumer appeal and understanding of student-made products, and (2) strengthening students' digital competence and creativity in applying creative industry technology. This innovation is expected to become a model for adaptive digital marketing implementation in the Indonesian vocational education environment that emphasizes collaboration between technology, pedagogy, and the local cultural context. This study also reports on the feasibility of AR as a medium for presenting TEFA products and its suitability as a learning module and teacher assistance in vocational schools.

METHOD

This study used a Research & Development (R&D) design with a Design Thinking (DT) framework as the core approach to designing user-centered solutions, including the stages of Empathize, Define, Ideate, Prototype, and Test. The research was conducted at the TEFA Multimedia Skills Program unit of SMKN 1 Sumenep, focusing on the development and testing of AR promotional media for packaged products (snacks, nuts, anchovies, potato chips).

Empathize Stage

Researchers mapped stakeholder needs through interviews and field observations. The empathy focus included: (i) the limitations of conventional promotion (static, difficult to visualize advantages), (ii) preferences for easily accessible digital channels, and (iii) the context of local food packaging (identity, nutritional information, product storytelling).

Figure 1. Joint observation by students and teachers of the TEFA unit

Define Stage

The findings from the empathy stage were synthesized into the following problem statements:

"How to design AR-based promotional media that is accessible, informative, and interactive to increase the appeal of TEFA products?"

"How to provide AR-based promotional media learning to students and teacher guidelines to be able to produce AR application development to be applied to TEFA products?".

Ideate Stage

The ideate stage is carried out by compiling alternative solutions through brainstorming, worst possible ideas (to reveal sources of failure and then turn them into design criteria), and SCAMPER. Ideas are then selected until a concept is obtained:

1. AR Label and 3D Packaging Model Design: Markers on the label trigger a 3D animation showing the hygienic production process, local ingredients, nutritional information, and brief testimonials (Fig. 2).

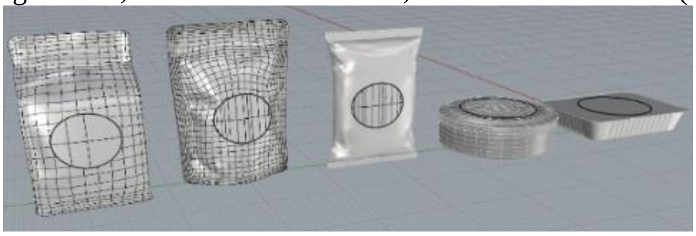

Figure 2. 3D Product Packaging Design.

2. AR digital catalog: product scenes with rotation or zoom, UI overlay (product, price, description).
3. Social activation: Capture images of AR product displays to be used as campaign teasers on social media.
4. The selection of ideas takes into account the learning that vocational school students can master (Unity, Vuforia) and guidance from teachers.

Prototype Stage

A functional prototype was developed using the Unity and Vuforia (Android) pipeline with content including: 3D product objects, process animations, UI overlays with product information, materials, and AR product screen capture publications to social media as campaign teasers (Fig. 3). The use of marker-based AR with the Unity and Vuforia pipeline is in line with common practices in vocational training/TEFA as mapped by the latest systematic review." (Chiang et al., 2022).

Figure 3. Scan AR Product Prototype and Marker.

On the initial display of the prototype, users can scan markers designed from the existing product menu. Each product menu is a marker that will display samples of 5 3D packaged products that have been produced. Each 3D product created has a view information and save object button. When the user selects view information, product information will be displayed, namely the name, price, description, photos, and videos loaded in the application display. When the "Save Object" option is selected, the 3D object will be saved for later use as a medium to display the 3D object in the real world (non-marker area) to visualize the 3D product in a real environment. It can also be saved as an image to be posted on social media (Fig. 4). The use of textures and 3D objects follows the SMK packaging products created from the observations that have been conducted.

Figure 4. Packaging and Product Design by SMKN 1 Sumenep.

Test Stage

This study obtained written approval from the school (SMKN 1 Sumenep) and was conducted with informed consent from all participants. Participation was voluntary, participants could withdraw at any time, and data were reported in aggregate form without personal identification. The study complied with the principles of confidentiality, participant safety, and applicable educational research ethics. The study involved 55 respondents (50 students and 5 teachers) from the Multimedia Skills Program. Inclusion criteria: (i) involved in/witnessed the AR prototype demo, (ii) willing to fill out a questionnaire, (iii) used an Android device for the scanning test. Sampling technique: convenience sampling during the test session in the school hall. The 5-point Likert questionnaire (1 = strongly disagree to 5 = strongly agree) covered the following constructs: (C1) Attractiveness/effectiveness of promotion; (C2) Product understanding; (C3) Perceptual UX/usability; (C4) Uniqueness/USP; (C5) Adoption intention. Sample item: "AR on the packaging helps me understand product information more quickly." Observations and questionnaires were conducted to identify barriers, UI/UX suggestions, and scanning stability. Test sessions were conducted face-to-face (±45–60 minutes): 5-minute briefing → 15–20-minute task test → 10–15-minute questionnaire completion. Markers were placed at several points with the AR prototype (Fig. 5).

Figure 5. Testing Students of SMKN 1 Sumenep on AR Prototype and Marker.

The questionnaire covers four main constructs: attractiveness (A), understanding (U), usefulness/UX (UX), and adoption intention (AI). Some supporting items measure promotion/USP (PR), AR element preference (PF), and economics/cost (EC). Likert items use a 1–5 scale (1 = strongly disagree to 5 = strongly agree), while some variables are measured ordinally (3–4 points) or dichotomously (Yes/No) according to the nature of the question (see Table 1). Construct scores were calculated as the mean of the Likert items per construct; categorical/dichotomous items were reported as proportions or distributions and were not combined into Likert scores. Reverse items were not used. Score mapping for ordinal variables: (i) promotion effectiveness 1–4 (less effective→very effective), (ii) comprehensiveness 1–4 (not comprehensive→very comprehensive), (iii) difficulty 1–4 (very difficult→very easy, or reversed for consistency). Validity & reliability. Content validity was obtained through expert judgment. Cronbach's α was calculated only for constructs with ≥2 Likert items; $\alpha \geq 0.70$ was considered adequate. Analysis Reported percentages, mean–SD, and 95% CI for Likert constructs; descriptive student–teacher comparisons; and proportions/95% CI for AI1 and EC1.

RESULTS AND DISCUSSION

This section presents the findings of the development and testing of Augmented Reality (AR) presentation media for TEFA products at SMKN 1 Sumenep, organized into the following sub-sections: (A) Assessment of Visual Design and AR Elements, (B) Perception of Technical Difficulty and User Experience (UX) Quality, (C) Analysis of Selling Points, Product Uniqueness (USP) and Costs, (D) Impact on Education, Promotion, and Interest in Self-Development, and (E) Recommendations for Improvement.

Assessment of Visual Design and AR Elements

In general, respondents gave positive assessments of the visual design quality of product packaging prior to AR implementation, with the majority responding "Good" and "Very Good" (Fig. 6).

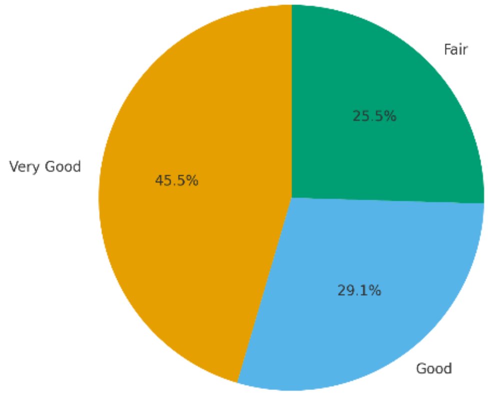

Figure 6. Visual Assessment of Packaging: Very good 45.5%.

This shows that the packaging design is considered solid in terms of layout, typography, and color. When asked about the most prominent AR element, respondents' answers were divided between 3D product animation and interactive nutritional information (Fig. 7).

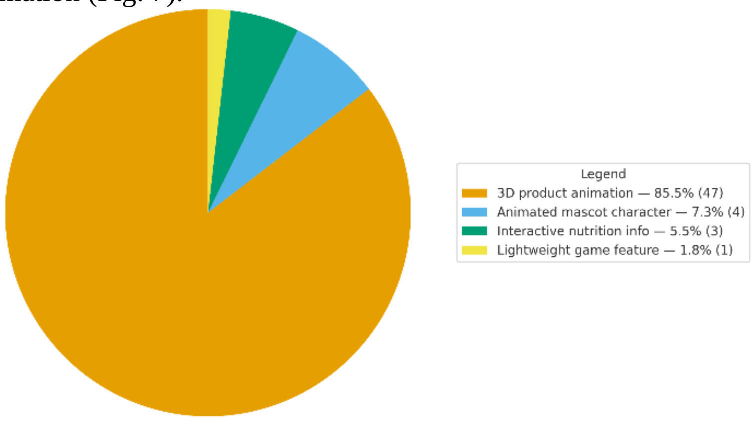

Figure 7. Favorite AR Element: 3D Animation 85.5%.

Positive assessment of basic packaging design is an important asset. This means that AR technology is not there to cover up poor design, but rather to enrich designs that are already well received. The choice of prominent AR elements (3D animation and nutritional information) indicates that students see two main values in AR: visual appeal (aesthetics) and informative function (utility). 3D animation satisfies the "wow factor" and product visualization aspects (85.5%), while interactive nutritional information addresses consumers' need for easily accessible and understandable data (5.5%).

Perception of Technical Difficulty and Quality of User Experience (UX)

Most students felt that the process was "difficult" (38.2%) and "easy" (32.7%) (Fig. 8). For User Experience (UX) improvements, the most common suggestions were:

1. Improved UI/UX Design: The appearance of the scanner application was considered unattractive. Respondents suggested improving the display scheme for the scanner area by adding color, contrast, and text layout to make it neater, more suitable for scanning AR markers, and more unique.
2. Improving Asset Quality: The quality of the images or 3D models that appear is considered to be unclear or "gray".
3. Addition of Functional Features: There are requests to add features such as purchase links, sales location information, and QR-Code payments directly from the AR application.

The perception of high difficulty reflects students' awareness of the technical complexity behind AR technology (Accardi et al., 2025). This is a realistic finding and shows that they do not underestimate the production process. On the other hand, this also signals the need for educational institutions to strengthen AR-related curricula or training to boost student confidence. Optimizing VR/AR in vocational education emphasizes task design, contextual relevance of practice, and system performance metrics (latency/FPS/tracking) to ensure a stable learning experience (He et al., 2024).

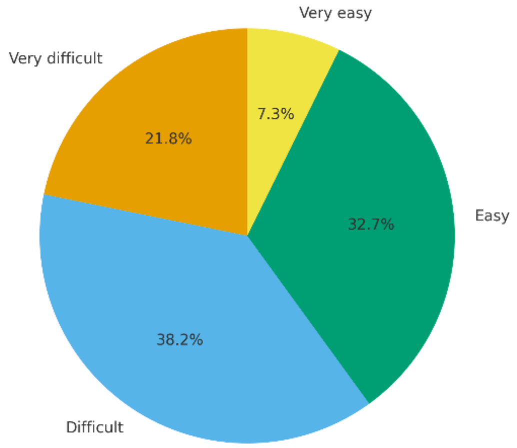

Figure 8. Technical Difficulty Level of AR: Difficult 38.2%.

The suggestions provided were very constructive and user-oriented. This shows that students are not only able to assess from a technical perspective, but also have sensitivity towards the end user experience. These findings are in line with studies that place immersive technology as a lever for learning experiences and user interaction in the classroom (Vashisht, 2024).

Analysis of Sales Value, Product Uniqueness (USP), and Costs

The majority rated AR as very effective (81.8%), including 47.3% who rated it as 'very effective' (Fig. 9).

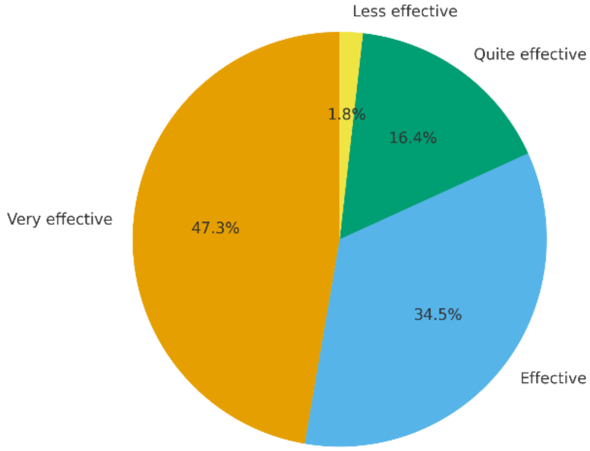

Figure 9. Perception of Promotion Effectiveness: Very effective 47.3%.

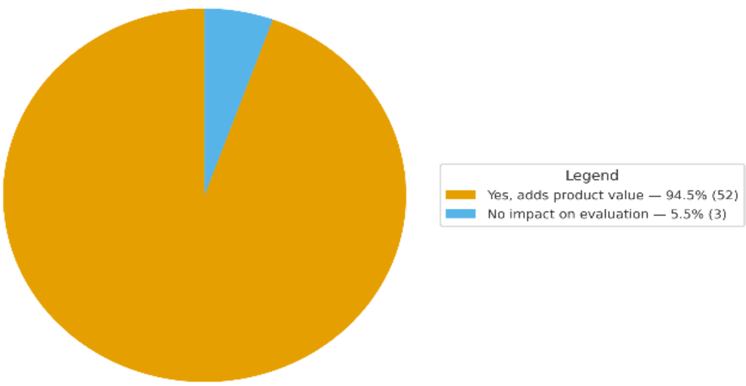

Figure 10. Views on Production Costs vs. Added Value: Yes 94.5%, No 5.5%.

The increase in the perception of 'effectiveness' in product presentations via AR is in line with AR marketing findings that link vividness–interactivity to engagement and purchase intent." (Yang & Lin, 2024; Söderström, 2024). It is consistently stated that the use of AR provides a strong Unique Selling Proposition (USP) in the local market, especially in the Sumenep area, Madura (Fig. 10). Augmented digital humans in storytelling advertisements have been proven to increase marketing processing and response, strengthening the role of immersive narratives in brand experiences (Sung, Kim, & Choi, 2023). Regarding costs, respondents believe that adding AR technology "will provide added value to the product that is commensurate with the cost, rather than being a disproportionate expense." Students have high confidence in the commercial potential of AR technology. This view is in line with modern marketing trends where interactive experiences are a significant selling point. These results are consistent with the literature reporting increased engagement and conceptual understanding when material is presented through AR (Nan, 2025; Singh, Garg, & Soni, 2024).

The Impact of Education, Promotion, and Interest on Self-Development

Most respondents felt that the TEFA project successfully provided a "very comprehensive" (54.5%) overview of the industry workflow, from concept to implementation (Fig. 11).

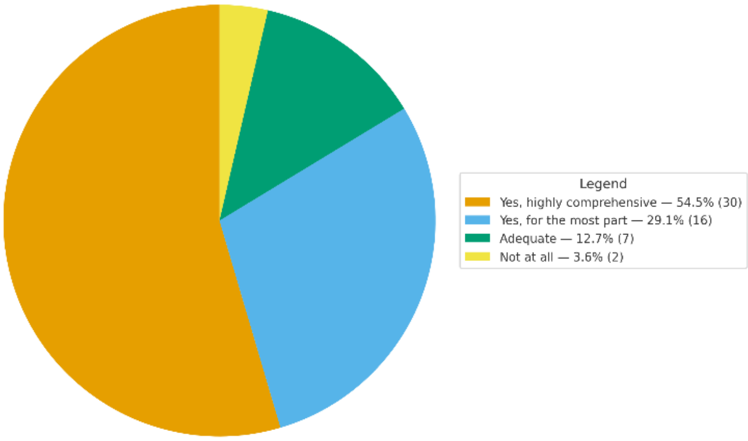

Figure 11. Comprehensiveness of Industry Flow: Very comprehensive 54.5%.

Almost all respondents answered "Yes" (85.5%), indicating that they are willing to use and explore AR technology after receiving training or seeing its implementation (Fig. 12).

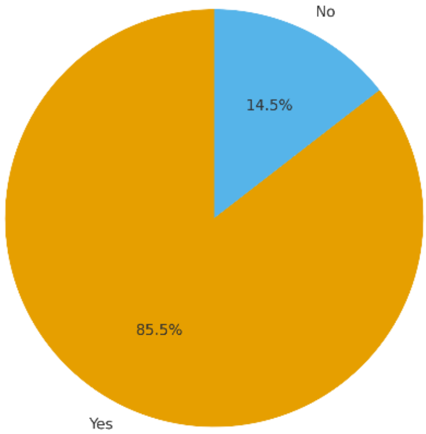

Figure 12. Responses to AR Technology Use: Yes 85.5%

Students have high confidence in the commercial potential of AR technology. They see it as a key differentiator that can enhance the image of TEFA products in the eyes of consumers. This view is in line with modern marketing trends, where interactive experiences have become a significant selling point. These results are consistent with evidence of AR utilization for tourism promotion—a similar domain in terms of communication needs and experience (Ranawijaya, Iryanti, & Ferdinanda, 2020)—as well as the application of mobile AR in tourism education, which has been proven to increase engagement and access (Puja, Winatha, & Aryasih, 2025).

Recommendations for Improvement

Most respondents felt that the TEFA project successfully provided an overview. Overall, the response from Multimedia Vocational School students was very positive. They viewed the AR technology on TEFA product packaging as a relevant innovation, one with high selling value, and one that provided a valuable learning experience.
Recommendations Based on the Study:

1. Prioritize UI/UX Improvements: The TEFA development team should focus on student suggestions to improve the application interface design, visual asset quality, and information layout.
2. Consider Adding Features: Future development plans could include the integration of commercial features such as e-commerce links, location maps, or digital payments to make the AR experience more functional.
3. Integrate into the Curriculum: Given the high level of student interest and perceived difficulty, schools could develop more in-depth AR training modules to improve students' competence and confidence.
4. Utilize as a Marketing Tool: Students' belief in the promotional potential of this product should be actively leveraged by schools in new student recruitment campaigns and departmental promotion.

Implementation Details and Replicability Notes

This section complements the development report by describing key implementation decisions that affect replicability, classroom feasibility, and sustainability of AR-based TEFA promotion. The prototype in this study was built using a marker-based pipeline (Unity–Vuforia, Android). The interaction concept was designed to remain accessible for vocational high school learners while still providing meaningful AR value for product presentation. Specifically, each TEFA product label/menu was treated as a marker, which triggers a 3D packaged-product visualization accompanied by UI overlays and supporting media. On the initial screen, users scan the marker and the application renders a 3D packaging model. Users then interact with two main actions: (1) “View Information” and (2) “Save Object”. The “View Information” action opens structured information about the product, including the product name, price, description, photos, and videos. The “Save Object” action stores the rendered 3D object to enable later placement in a non-marker environment, allowing users to present the product in a real scene for contextual visualization; it can also be captured as an image for social media activation. This approach was intentionally aligned with the ideation outputs (rotation/zoom catalog, UI overlays, and social activation), while keeping the interaction steps simple enough to be delivered as a TEFA learning module.

From a technical perspective, three implementation areas are crucial for stable performance and consistent user perception: marker quality, 3D asset optimization, and UI scanning ergonomics. First, marker quality (contrast, uniqueness, non-repetitive patterns) strongly affects tracking stability. In TEFA contexts, labels are often visually dense and include repetitive elements; therefore, marker design should prioritize distinctive feature points and sufficient contrast. Second, 3D asset optimization is necessary for smooth mobile AR, especially in classrooms where device specifications vary. The findings that respondents perceived technical complexity as difficult/very difficult (total 60.0%) can be partly explained by the demands of integrating assets, maintaining tracking stability, and ensuring real-time rendering performance. Recommended practices include: (i) preparing multiple levels of detail (LOD) for packaging models, (ii) compressing textures and limiting real-time lighting complexity, (iii) reducing draw calls via atlasing and material consolidation, and (iv) ensuring video assets are encoded at mobile-friendly resolutions and bitrates. These steps directly address user feedback about “gray/unclear” assets and help maintain consistent visual quality across devices.

Third, UI scanning ergonomics should be treated as part of the “tracking environment,” not merely interface decoration. Respondents explicitly suggested improving the scanner UI with better layout, color scheme, and guidance to make the scanning process clearer and more attractive. Practically, this can be translated into: (i) providing on-screen prompts indicating scanning distance and lighting recommendations, (ii) showing a tracking status indicator (e.g., “Searching marker / Marker found / Tracking lost”), and (iii) simplifying the initial screen to reduce distractions during marker acquisition. Better scanning ergonomics can reduce cognitive load and make the first-time AR experience feel more “effortless,” which is particularly important for TEFA promotion where users may scan casually at events or exhibitions.

Pedagogical Integration as a TEFA Module and Practical Implications

Beyond promotion, this AR label system can be structured as a TEFA learning module that strengthens students’ digital production literacy and entrepreneurial communication skills. The implementation naturally maps to a Design Thinking workflow (Empathize–Test), allowing teachers to scaffold the project as an end-to-end production cycle. A recommended classroom sequence is: (1) product identity/story mapping (emphasizing what differentiates the product, local ingredients, hygiene workflow, and value propositions), (2) marker/label design iteration, (3) 3D packaging creation and animation planning (prioritizing clarity and "micro-storytelling"), (4) Unity–Vuforia integration and UI overlay design, (5) user testing with structured tasks (scan → explore info → save object → capture for social media), and (6) reflection and improvement based on user feedback. This sequencing supports the dual goals described in the study: increasing consumer appeal and understanding, while strengthening students' competence in creative-industry technology application.

The preference pattern observed—where 3D animation became the most appreciated AR element (85.5%)—suggests that "experiential visualization" is a core value driver for TEFA presentation. In marketing terms, 3D animation provides vividness and a "wow factor" that can differentiate TEFA products in a local market. In learning terms, it offers an actable artifact that students can design, iterate, and evaluate through user testing. However, the same feature can increase production complexity (modeling, rigging/animation, optimization), which explains why usability/technical difficulty remains a non-trivial barrier. Therefore, a pragmatic pedagogical strategy is to begin with a "minimum viable AR" approach (static 3D model + simple rotation + short UI information), then progressively introduce animation and richer media (video/testimonials) only after tracking stability and UI clarity are achieved. This approach is consistent with respondent feedback and helps ensure sustainability of implementation in vocational learning contexts.

The promotional implications are also practical for school branding and TEFA commercialization. Respondents perceived AR promotion effectiveness as effective/very effective (81.8%), and a large majority perceived the value added as economically feasible compared to costs. The application therefore has potential not only for product selling but also for showcasing TEFA workflows as a "signature capability" in recruitment and exhibitions. To maximize this potential, the AR experience should be explicitly connected to calls-to-action (CTAs), for example: a purchase link, location map, or QR-based payment, as already suggested by respondents. These features shift the AR label from "informational novelty" to "functional conversion support," which can be further evaluated through performance indicators such as scan-to-action rate and repeated use.

Limitations and Future Work

This study provides a feasibility-focused development report with descriptive acceptance results. Several limitations should be acknowledged to strengthen the manuscript for broader publication contexts. First, the sampling used convenience sampling during a demonstration session, and teacher participation was limited compared to student participation. Second, the evaluation primarily captured perceived effectiveness, perceived understanding, perceived UX/usability, and adoption intention. While these are meaningful for feasibility, they do not directly measure behavioral outcomes such as actual purchase intent conversion, time-to-understanding, or recall retention. Third, mobile AR performance can vary significantly across devices due to camera quality, processing capability, and environmental lighting; thus, generalization of scanning stability across contexts should be made cautiously.

Future work can strengthen both scientific contribution and TEFA scalability in three directions. (1) Experimental evaluation: compare AR vs. non-AR packaging in controlled tasks and measure objective outcomes (e.g., time to find key product information, recall after a delay, and willingness-to-buy indicators). (2) Technical refinement: standardize cross-device asset pipelines (LOD rules, texture compression presets, performance profiling targets such as minimum FPS and tracking robustness under different lighting), aligned with the study's recommendation to refine UI/UX and 3D asset quality. (3) Market integration: incorporate CTA features (buy/location/QR links) and measure post-scan engagement metrics (click-through, saved-object usage, share rate). These directions align with the study's stated next development focus and help bridge feasibility findings into sustainable TEFA deployment at scale.

CONCLUSION

This study confirms that Augmented Reality (AR) is suitable for adoption as a medium for presenting Teaching Factory (TEFA) products at SMKN 1 Sumenep. The packaging design before AR was rated positively (Good–Very Good 74.6%), while the most appreciated AR element was 3D animation 85.5% (followed by a moving mascot 7.3% and interactive nutritional information 5.5%). From a promotional perspective, AR was perceived as effective–very effective 81.8% (including "very effective" 47.3%), and in the field of vocational education, the description of industrial workflows was rated "very comprehensive" 54.5% (total very comprehensive + mostly 83.6%). Adoption interest is not universal, but remains high (85.5% "Yes"). On the implementation side, challenges related to usability/technical complexity are still felt (difficult 38.2%; very difficult 21.8%; total 60.0%), so simplifying the UI/UX (scanning flow, tracking indicators), optimizing 3D assets (LOD, texture compression), and adding CTAs (buy/location/QR links) are priorities in order for interest to lead to concrete action. Overall, AR enhances appeal and enriches product understanding, making it relevant to continue as a TEFA project. The next development focus is directed at (i) UI/UX improvements, (ii) standardization of cross-device 3D asset pipelines, and (iii) integration of marketing performance indicators (purchase interest, conversion, repeat usage) in evaluations, so that the impact of AR on TEFA's learning outcomes and business performance can be mapped comprehensively and sustainably.

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