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From Craft to Science: Embedding Physics of Materials into Product-Based Learning in Cosmetology Education

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Abstract: Fantasy hair styling in vocational cosmetology is commonly treated as a tacit craft activity, leaving limited evidence that material and geometry choices lead to ergonomic and stable designs. This study aimed to develop and validate craft-based support frames for fantasy buns while making materials-science and basic biomechanics concepts explicit. Using a 4D Research and Development model (Define–Design–Develop–Disseminate), undergraduate cosmetology students produced three frame variants (foam, thin wire, and polymer mesh). Product quality was evaluated by three cosmetology/beauty-education experts using a 1–5 Likert rubric covering aesthetics (neatness, proportion, creativity, harmony) and ergonomics (comfort, lightweight, ease of application/removal, positional stability). Three models conducted short wear-and-movement trials (standing, walking, head turns). Quantitative scores were converted to percentages and categorized; expert comments were analyzed thematically. Aesthetic performance averaged 87% (Very Good: neatness 90%, proportion 85%, creativity 88%, harmony 85%). Ergonomic performance averaged 83% (Very Good: comfort 85%, lightweight 82%, ease 80% [Good], stability 85%), with frame weights ranging from ~500 to 2,000 g. These results indicate that craft-based frames can produce visually coherent and ergonomically acceptable fantasy buns while supporting concept-based reasoning; future work should strengthen durability and application techniques and extend trials to longer wear durations.

Keywords: Biomechanics; Hair Design; Materials Science Education; Physics of Materials; Product-Based Learning

Introduction

Craft materials commonly used in arts and crafts, hold great potential as a source of innovation in aesthetic hair styling. The variety of textures, colors, and shapes of craft materials provides opportunities to enrich visual creativity while fostering sustainable practices through the use of local and alternative resources. Several studies in various fields have shown that integrating craft materials with learning can enhance creativity and broaden students' perspectives in their work. However, research specifically examining the application of craft materials in hair styling innovations within vocational learning is still very limited. This study aims to develop and test fantasy hair styling products that utilize craft materials as a vocational learning medium. This innovation was created by students in the cosmetology education program and assessed by experts based on aesthetic and ergonomic aspects. The research results are expected to contribute not only to the enrichment of vocational learning in cosmetology education, but also to the development of creative and sustainable innovation in the beauty industry.

Accordingly, this 4D R&D study reframes fantasy hair construction as a materials-science learning task in

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vocational science education. We (i) integrate physics-of-materials and polymer concepts into instruction, (ii) produce craft-based frames from foam, thin wire, and polymer mesh, and (iii) evaluate outcomes through expert product rubrics (aesthetics, ergonomics) and science-education evidence (students' concept use and process skills documented in design rationales and task performances). This alignment positions the work squarely within the Science & Science Education focus while preserving authentic vocational relevance (Pratiwi & Ikhsan, 2024; Zahirah et al., 2024).

In addition to psychomotor skills, vocational education must also produce learning outcomes related to creativity and innovation. In science and physics learning, PBL combined with virtual media assistance has been shown to enhance students' creativity by enabling richer exploration and visualization of concepts, while also fostering more meaningful learning experiences (Gunawan et al., 2017). This finding is important because it demonstrates that well-designed PBL not only strengthens work-related skills but also promotes creative thinking, which is increasingly essential for dealing with job complexity and the challenges of industry and entrepreneurship. However, the success of PBL is highly dependent on the quality of learning tools and the design of its implementation. PBL should not be understood merely as "project assignments", but as a systematic approach requiring clear objectives, learning steps, worksheets, instruments for assessing both process and product, and competency achievement indicators. In the vocational context, the systematic development of PBL learning tools using a model such as 4D is relevant because it provides clear stages from defining needs, designing, developing, to disseminating learning tools (Muslim et al., 2020).

In other words, PBL will be more effective when supported by well-structured and replicable learning tools. On the other hand, vocational education also develops approaches that emphasize tangible outputs or products, such as production-based learning or product-based learning. This approach places the production process at the core of learning, so that achievements are reflected not only in classroom activities but also in the quality of the products generated. An evaluation of production-based learning implementation in vocational settings suggests that such programs should be assessed comprehensively through context, input, process, and product components to ensure alignment with vocational goals and workplace needs (Sadrina et al., 2018). In this sense, evaluation is essential to ensure that PBL or production-based learning does not remain at the level of activity, but produces meaningful impacts on students' competencies. Product-oriented approaches are also relevant when learning is directed toward strengthening entrepreneurship and graduates' readiness to create added value. In vocational higher education, the implementation of a product-based entrepreneurship module has been reported to support learning outcomes because students learn to design, produce, and evaluate outputs with economic value (Yulastri et al., 2018). This finding reinforces the argument that vocational learning becomes stronger when students not only "perform practical tasks" but also understand planning aspects, product quality, and value creation. Based on the discussion above, PBL and product-based learning demonstrate strong potential to strengthen vocational competence through improved psychomotor skills (Sumarni et al., 2016), enhanced creativity through appropriate learning media (Gunawan et al., 2017), and product- and entrepreneurship-oriented learning outcomes (Yulastri et al., 2018). Nevertheless, a common challenge is the lack of readiness in learning tools and implementation designs, which may cause PBL to become merely a project activity without clear measures of process and product achievement. Furthermore, the absence of comprehensive evaluation may prevent product-based learning from providing convincing evidence of its effectiveness in improving competence (Sadrina et al., 2018).

Vocational education requires learning that goes beyond theoretical mastery and ensures that students demonstrate measurable occupational competencies, including procedural skills, product quality, and readiness to meet industry standards. Therefore, learning should be oriented toward authentic experiences that encourage students to plan, execute, and evaluate work systematically, so that learning outcomes can be justified both academically and professionally. One approach that aligns well with these needs is Project-Based Learning (PBL). PBL positions a project as a vehicle for learning that demands planning, problem solving, collaboration, and decision making throughout the task. Empirical evidence shows that PBL is effective in strengthening key competence dimensions in vocational settings, particularly psychomotor skills that determine the quality of practical performance (Sumarni et al., 2016). Thus, PBL is relevant as a strategy to bridge learning objectives with tangible skill development. Beyond psychomotor competence, vocational and science learning should also strengthen creativity and conceptual understanding. In physics learning, PBL supported by virtual media has been shown to enhance students' creativity by enabling richer exploration and visualization of concepts (Gunawan et al., 2017). This evidence is consistent with findings on PhET simulation assisted PBL, which improves students' creative thinking skills in elasticity topics (Doyan et al., 2023). These results suggest that strengthening PBL through appropriate media and simulations can enrich learning experiences while improving creative competence outcomes.

PBL can also contribute to improved cognitive learning outcomes when its implementation is designed to fit the characteristics of the content. In physics, the application of PjBL has been reported to influence students' learning outcomes in direct current circuit topics (Selasmawati & Lidyasari, 2023). In addition, the development of PBL with a STEAM approach integrated with science literacy has been shown to enhance learning outcomes, indicating that PBL becomes more effective when anchored in clear literacy and conceptual frameworks (Nuraini et al., 2023). Together, these findings reinforce that PBL is not merely a "project assignment" but a strategy that can be optimized to improve learning outcomes through appropriate pedagogical design. However, the effectiveness of PBL depends heavily on the quality of learning tools and the implementation design. PBL requires clear objectives, operational learning steps, worksheets that guide the process, and assessment instruments that evaluate both process and product. In vocational contexts, the development of PBL tools using the 4D model is relevant because it provides systematic stages from needs definition to dissemination of validated learning tools (Muslim et al., 2020). Similarly, a product orientation is important when learning is directed toward work readiness and entrepreneurship, as demonstrated by product based entrepreneurship modules that support learning outcomes in vocational higher education (Yulastri et al., 2018).

At the same time, project and product based learning must be supported by comprehensive evidence so that it does not stop at activities but produces measurable competence gains. An evaluation of production based learning implementation highlights the need for holistic review through context, input, process, and product components to ensure alignment with vocational goals and workplace needs (Sadrina et al., 2018). On this basis, research that develops and evaluates project and product based learning is important to ensure measurable competence improvements, strengthen the relevance of learning to professional practice, and provide scientific foundations for replication and continuous refinement in similar educational contexts (Anwar et al., 2024; Hayat et al., 2023).

Project-based learning is increasingly positioned as a learning model that can cultivate 21st-century competencies, particularly when students are required to plan, collaborate, and complete authentic products as learning evidence (Mayasari et al., 2016). In science-related learning, the impact of PjBL can be strengthened when supported by digital or virtual media that enables richer exploration, which has been reported to improve students' creativity in physics learning contexts (Gunawan et al., 2017). Recent studies in broader engineering and applied science education further reinforce the value of PBL as a pathway to both competence development and innovation oriented outcomes. A longitudinal case study shows that sustained PBL experiences can evolve beyond course projects into innovation practices and team based problem solving culture (Baldissera & Delprete, 2020). In design and manufacturing oriented learning, PBL has also been effectively used to train advanced CAD and CAE competencies, indicating its strong alignment with industry relevant tool mastery and authentic workflow simulation (Berselli et al., 2020). At the same time, a comprehensive review highlights that while PBL is widely implemented, its effectiveness depends on how it is operationalized, including clarity of learning goals, assessment design, facilitation, and resource readiness, and it also identifies common implementation challenges that must be anticipated Therefore, the development of project- and product-based learning tools or modules needs to be carried out systematically so that they can be implemented consistently and their impacts on students' competencies can be measured. The 4D development model offers a strong framework to ensure that the developed tools are aligned with needs, validated, and ready for broader use (Muslim et al., 2020). Within this framework, research focusing on the development of PBL tools or product-based modules is important to deliver vocational learning that is not only engaging but also measurable, impactful, and relevant to professional demands.

Method

This research employed a Research and Development (R&D) design using the 4D model developed by Thiagarajan, Semmel, and Semmel, which consists of four stages: Define, Design, Develop, and Disseminat (Alfiani & Sb, 2024). The purpose of this approach was to produce an innovative product in the form of aesthetic hair styling utilizing craft-based materials, and to evaluate its feasibility in vocational learning contexts. We employed a Research and Development **(**R&D**)** 4D model (Define–Design–Develop–Disseminate) to create and evaluate craft-based support frames for fantasy hair buns in a vocational setting. Beyond product quality, the study explicitly targeted science-education outcomes grounded in physics of materials and basic biomechanics (mass, density, center of mass, torque, and positional stability).

Time and location of research. This study was conducted at Cosmetology Education study program/skin and hair laboratory, Faculty of Engineering, Universitas Negeri Medan, Medan, Indonesia, during february 2025 to July 202 Type of research. The study employed a Research and Development (R&D) design using the 4D model

(Define–Design–Develop–Disseminate). Population and sample. The population comprised undergraduate cosmetology students enrolled in semester of year 2025/2026. A total of 79 students were included using purposive sampling. Undergraduate cosmetology students designed and produced fantasy bun frames using foam, thin wire, and polymer mesh. Three external experts (cosmetology/beauty education) acted as raters for product evaluation, and three models wore the products during ergonomic trials (standing, walking, and head-turn tasks). All participants provided written informed consent.

Development stages. The development procedure followed the 4D model. In the Define stage, a needs analysis was conducted to identify learning requirements in vocational cosmetology and to explore the potential of craft-based materials for application in hair styling. In the Design stage, the aesthetic styling concept and expert evaluation instruments were prepared. In the Develop stage, students constructed frames from foam, thin wire, or polymer mesh, then wrapped them with hair and decorations to achieve target shapes. During development, students received structured instruction that explicitly linked materials-science and biomechanics principles (e.g., how mass and geometry shift the center of mass, influencing torque and positional stability during movement).

Products were subsequently evaluated by three experts. In the Disseminate stage, limited dissemination was conducted through documentation of students' works and publication submission. Data analysis. Quantitative ratings from expert assessment were analyzed descriptively by calculating mean scores and converting them to percentages, then interpreting them using predefined feasibility categories. Qualitative feedback from experts and observations during ergonomic trials were analyzed thematically to summarize key strengths and revision priorities for each material-based prototype.

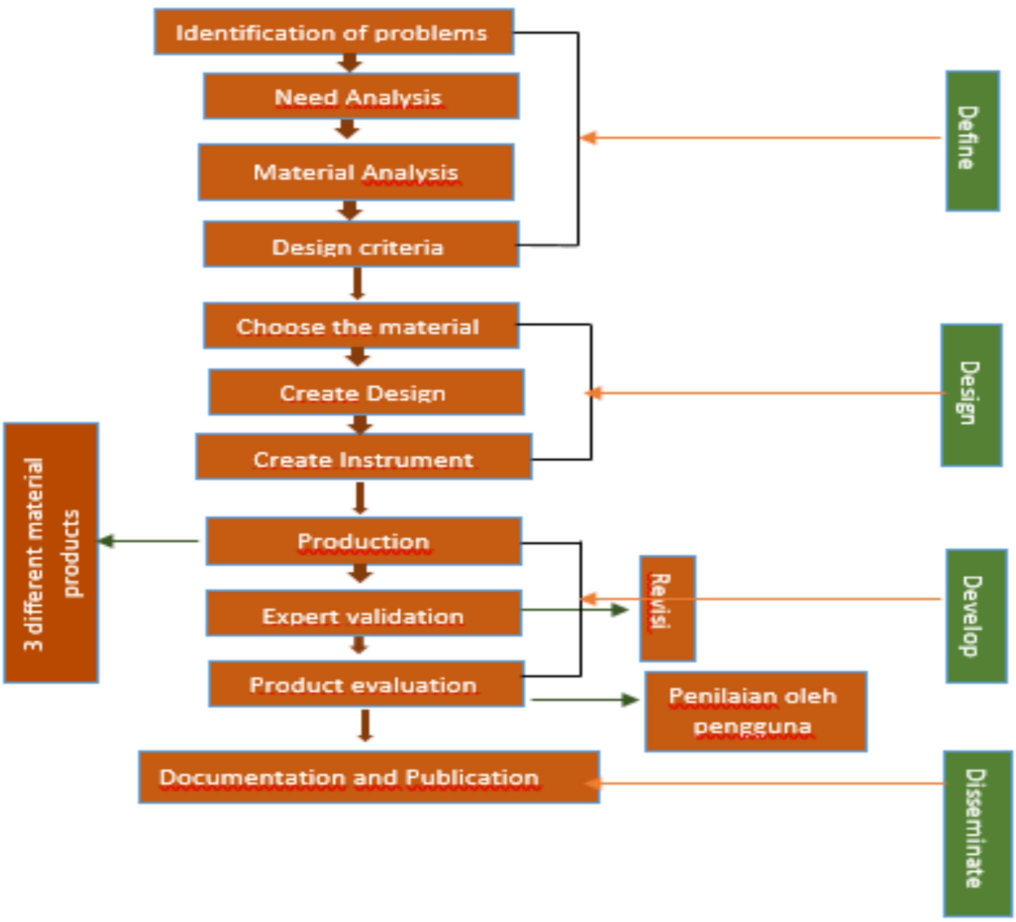

Figure 1. Research Design

Product assessments were conducted by three external experts in cosmetology and beauty education. The evaluation rubric covered two main aspects: (1) aesthetics (neatness, proportions, creativity, and harmony) and (2) ergonomics (comfort, lightweight, ease of application and removal, and positional stability during movement). The instrument used a 1–5 Likert scale, where 1 indicated "very poor" and 5 indicated "very good." In addition to quantitative ratings, experts provided qualitative comments as feedback for improvement.

Quantitative ratings were analyzed descriptively by calculating mean scores for each aspect and converting them into percentage values using [your formula/approach], then interpreting the results with predetermined feasibility categories (Very Good/Good/Fair/Poor/Very Poor). Qualitative comments were analyzed thematically to identify recurring strengths, weaknesses, and revision priorities for each product.

Table 1. Criteria validation test results

Criteria	Scale	Interval (%)
Very good	5	85 ≤ score ≤ 100
Good	4	69 ≤ score ≤ 84
Fair	3	53 ≤ score ≤ 68
Poor	2	47 ≤ score ≤ 52
Very Poor	1	20 ≤ score ≤ 36

Result and Discussion

Result

Result of Product Developed

The product developed has the following main product characteristics. The main materials used in making fantasy hair (fantasy buns) include foam, thin wire, and plastic netting.

Figure 2. Foam, wire, plastic mesh

Fantasy hair (fantasy buns) weigh between 500 and 2,000 grams. The 2,000-gram weight is found in fantasy hair (fantasy buns) made from netting. This is due to the large size, volume, and height of the bun. This was done to determine the model's response to the bun (comfort, precision of shape, and balance). The construction (frame) that forms a strong and balanced bun. The frame is selected from foam, wire, and plastic netting. The frame will then be wrapped/covered with hair and ornaments that will beautify the shape of the bun. For this reason, the frame is chosen to be strong and shaped in such a way as to achieve the balance of the fantasy hair (fantasy bun) produced. The craft material frame is of course not standing alone, like the foam craft material, there is also the addition of a little wire to support the bun that will be placed on the model's head.

The support structure for fantasy hair (fantasy buns) is made from craft materials and can be attached to the head and conforms to the head (ergonomic). Visual beauty is the final step in perfecting the fantasy bun. Therefore, it is necessary to add color and other supporting ornaments to achieve the desired result.

Result of Prototype and Variant Results

The developed prototypes of fantasy bun support frames were produced in three material variants: foam, thin wire, and plastic mesh. Each prototype was designed to function as an internal structure that supports bun volume and shape, while remaining feasible for student production in a vocational cosmetology setting. The three variants represent different material characteristics and fabrication approaches, allowing the product outcomes to be documented and compared based on the resulting form and construction.

The first prototype uses foam craft material as the main support medium. This prototype was shaped by cutting and forming foam into a bun volume that can be attached securely to the hair base and covered with hair elements during styling. As shown in Figure 1, the foam based frame produces a rounded bun form with a clear volume profile and a compact structure, serving as a stable base for fantasy bun assembly. The second prototype employs thin wire as the primary material to form the bun frame. In this variant, the wire is bent and arranged into a structural outline and reinforcement that determines the bun contour and supports the placement of hair components. As presented in Figure 2, the wire based frame shows a visible skeletal structure that defines the bun shape, and it is constructed to allow fastening points for additional hair elements and connectors.

The third prototype applies plastic mesh as the structural body of the bun frame. In this prototype, the mesh is rolled or formed to create bun volume, then secured to maintain its shape before hair is arranged on the outer surface. As illustrated in Figure 3, the plastic mesh frame results in a volumetric bun form with a textured surface structure, providing multiple attachment points for hair positioning and reinforcement. Across the three variants, the key outputs recorded in this stage include the completed frame form, the primary material used, and the visible construction characteristics of each prototype as documented in the figures. The foam variant emphasizes a solid body structure, the thin wire variant emphasizes a contour defining frame, and the plastic mesh variant emphasizes a formed volume structure. These outputs were documented as the tangible products generated from the development process prior to validation and trial stages. Overall, the prototype development stage produced three distinct fantasy bun support frames that were ready for subsequent assessment. The documentation of Figures 3-5 captures the physical appearance and construction outcomes of each material variant, ensuring that the product results can be traced clearly to the selected material and fabrication approach. These prototypes then served as the basis for further evaluation in the next sections, including expert validation and product trials.

Figure 3. Fantasy bun made of foam craft material

Figure 4. Fantasy bun made of thin wire craft material

Figure 5. Fantasy bun made of foam craft material

Product trial ergonomic results

The research results showed that the resulting fantasy hairstyle met ergonomic and aesthetic requirements, categorizing it as "Very Appropriate." The aesthetic assessment obtained an average score of 87% (Very Appropriate) with the following indicators: neatness of the bun shape (90%), appropriateness of the design proportions (85%), creativity and originality of the design (88%), and harmony of colors and accessories (85%). The ergonomic assessment obtained an average score of 83% (Very Appropriate) with the following indicators: comfort during use (85%), lightness and ease of installation and removal (82%), ease of installation and removal (80%), and stability during movement (85%). Based on these results, it can be concluded that the innovative fantasy hairstyle product developed using handicrafts is highly suitable for use, both for educational purposes and performances/competitions, as it combines visual beauty with comfort. This product also has the potential to serve as a reference for the development of ergonomic fantasy bun designs in the hairdressing field.

Students produced three fantasy-bun frame variants using foam, thin wire, and polymer mesh as primary craft materials. Frames were designed to be light and form-stable; observed weights ranged from ≈500 g to 2,000 g (heaviest for large-volume mesh constructions), reflecting intentional variation to probe comfort, shape precision, and balance during wear. The aesthetic aspect was assessed through a product validation test conducted by three hairdressing experts. The results of the study on the aesthetic aspect obtained the following percentages:

Table 2. Percentage of product validation test results

Indicator	Percentage%	Category
Neatness	90	Very Good
Proportion	85	Very Good
Creativity	88	Very Good
Harmony	85	Very Good
Average	87	Very Good

Ergonomic aspects were assessed through product trials with three makeup models (users). The results of the ergonomic research yielded the following percentages:

Table 3. Percentage of product trial assessment results

Indicator	Percentage Product trial result (%)	Category
Comfortness	85	Very Good
Lightweight	82	Very Good
Ease of Application	80	Good
Stability position	85	Very Good
Average	83	Very Good

Discussion

Comparison of Prototype Outcomes

The comparison of prototype outcomes across material variants is positioned as a product-focused learning result because the study produced three tangible prototypes that can be evaluated as "industrial products" in a vocational learning context. Presenting the variants side by side helps demonstrate how project based learning can translate classroom activities into concrete outputs that are observable, comparable, and assessable using clear criteria of product quality and usability (Yudiono, 2020). This approach aligns with the idea that vocational learning should emphasize authentic production experiences where learners generate products that can be reviewed for improvement and standardization (Ganefri & Hidayat, 2015).

A practical way to compare the three variants is to frame the analysis through product oriented indicators, such as structural form integrity, ease of assembly, visible neatness, attachment feasibility, and readiness for trial use. These indicators make the comparison systematic and help avoid purely subjective judgments. A structured evaluation mindset is consistent with the CIPP perspective, which encourages reviewers to examine the context and resources, the process of implementation, and the product output as a complete chain of evidence (Rebia et al., 2023). The existence of multiple variants also strengthens the "product" component because the outputs demonstrate design alternatives rather than a single trial object.

The foam variant represents a solid-body approach where the support frame is formed by shaping a compact volume that becomes the bun foundation. In prototype terms, this variant makes the product outcome easy to document visually because the bun volume and silhouette are immediately apparent, supporting clarity of design intent in Figure 1. The foam prototype therefore contributes an outcome that is directly aligned with "product appearance" as a measurable artifact of learning. The wire variant thus highlights the role of material choice in shaping how learners engage in design decisions during the project. The plastic mesh variant represents a formed-volume approach that produces bun size through rolling or shaping the mesh into a volumetric body. In Figure 3, this prototype is documented as a frame with a surface structure that can support attachments and reinforcement during styling. A mesh based prototype can support group work routines because it allows division of tasks such as shaping the body, securing the form, and preparing attachment points, which resonates with evidence that PjBL can strengthen collaboration skills alongside creative thinking when tasks require coordinated production steps (Yanti et al., 2023). The mesh prototype therefore adds an outcome that is not only a product artifact but also a context for collaborative production behavior.

The presence of three different variants strengthens the learning logic because it forces learners to compare alternatives and justify design choices, rather than merely completing one product. This comparative decision-making is important for cognitive outcomes because students must connect material properties, construction steps, and expected product performance into a coherent rationale. Research comparing PjBL with other inquiry-oriented strategies has shown that learning models that emphasize active construction and task completion can create meaningful differences in cognitive learning outcomes under appropriate instructional control (Kencana & Rifa'i, 2021). The prototype comparison stage, when documented clearly, becomes evidence that the learning task engaged higher-order reasoning rather than simple replication. The prototype comparison also provides a pathway to connect product development with science process skills such as planning procedures, controlling steps, observing outcomes, and revising based on trial evidence. A vocational-strength discussion benefits from linking the prototype outputs to the "industrial product subject" perspective because the learning deliverable is a product that can be judged against practical criteria. In this sense, presenting three variants demonstrates that learners are exposed to design alternatives and product constraints, which is closer to vocational practice than producing a single standardized object. Comparing prototype outputs across different materials is relevant because Project-Based Learning (PjBL) provides students with opportunities to test design alternatives and observe their consequences on product-oriented learning outcomes. Evidence from physics instruction indicates that project-based learning can improve learning outcomes compared to other approaches when students are directly involved in designing and completing projects that require conceptual understanding and technical decision-making throughout the work process (Hutapea & Simanjuntak, 2017). This supports the argument that comparing the three prototype variants (foam, wire, mesh) not only demonstrates differences in product form, but also reflects the thinking processes and strategy selection that occur during the project.

The evaluation dimension can be strengthened by mapping the three variants onto CIPP logic to explain why the comparison is educationally relevant. The context can be defined as the need for a feasible bun-support product that students can produce with accessible materials; the input includes material availability and student skills; the process includes construction steps and iteration; the product includes the final prototype forms shown in Figures 1–3. CIPP-based evaluation is commonly used to examine whether vocational product-based programs are implemented coherently and whether the product outputs align with program intentions (Rebia et al., 2023). This framing helps the prototype comparison read as a research-driven assessment rather than a descriptive showcase. Overall, the comparison of foam, thin wire, and plastic mesh prototypes provides a concrete basis for discussing how product-oriented projects generate diverse outcomes that can be assessed systematically. The prototype variants function as learning artifacts that reflect creativity, reasoning, and collaboration through tangible outputs, consistent with findings that PjBL supports creative thinking development (Sucilestari et al., 2023) and can strengthen collaborative and creative performance when implemented as a structured cycle (Yanti et al., 2023). The production-based orientation reinforces the vocational relevance by emphasizing product creation as the center of learning and evaluation (Ganefri & Hidayat, 2015), while the thinking-skill dimension is strengthened through comparative design decision-making embedded within the project task (Anazifa & Djukri, 2017).

Aesthetic Validation Findings

The findings show that the fantasy hair styling product using craft materials achieved a very good overall rating in both aesthetics and ergonomics. The high average scores indicate that the innovation is feasible and aligns with expert expectations, particularly in creativity, harmony, comfort, and practicality. This confirms that a product oriented task can generate outputs that are not only visually acceptable but also usable in a vocational learning setting. From the aesthetic perspective, the craft materials contributed to uniqueness and visual appeal by enabling exploration of color, texture, and form beyond conventional styling techniques. Expert appraisal suggests that incorporating craft elements encourages students to expand their design repertoire and produce cleaner, more coherent compositions while still maintaining originality in the final hairstyle. Quality improvement in aesthetic outcomes can be strengthened when students are supported by structured learning resources that guide step-by-step production and refinement. The development of project-based learning e-modules in vocational settings has been reported to facilitate more systematic learning processes and clearer task guidance, which can support students in achieving more consistent product results (Rahayu & Sukardi, 2021). In this study, the very good aesthetic validation scores can be interpreted as an outcome of structured production work in which students followed clear stages, enabling neatness, proportion, and harmony to be achieved more consistently.

Project-based learning implemented in laboratory-based settings has been reported to support the integration of conceptual knowledge with hands-on practice and to strengthen engineering design skills through iterative design and testing activities (Gomez-del Rio & Rodriguez, 2022).Emerging perspectives in materials education suggest strong potential for combining product-based learning strategies with technological support, including data-driven tools, to foster more adaptive learning and innovation-oriented thinking (Marquez et al., 2023).

Ergonomic Trial Findings and Practical Implications

Ergonomic performance also received a very good rating, although experts highlighted the need to refine durability and application techniques. This implies that creativity alone is insufficient if the product is not robust and easy to apply or remove. The results emphasize the necessity of balancing aesthetic ambition with functional feasibility so that the output remains relevant for professional practice. The aesthetic quality was rated very good overall, with an average score of 87%. The indicators were neatness 90%, proportion 85%, creativity 88%, and harmony 85%, showing that students were able to achieve clean forms and coherent visual arrangements while experimenting with nontraditional materials. These results support the interpretation that the prototypes can meet quality expectations at the level of product appearance. Structured learning scaffolds such as e-worksheets can strengthen students' reasoning and communication quality during project work, including the development of argumentation skills as part of science learning outcomes (Suyanto et al., 2024). In addition, product design that involves wearability and comfort benefits from a human-factor perspective, where updated anthropometric awareness is essential to inform design decisions and user fit, as highlighted in virtual fashion design contexts (Hartono et al., 2023).

Ergonomic performance averaged 83% in the very good category. Comfort and positional stability were both 85% (very good), lightweight was 82% (very good), and ease of application and removal was 80% (good). This pattern indicates that the frames generally balanced usability and stability during short standardized wear and movement tasks, while the application and removal procedures still require improvement through better attachment mechanisms and finishing. Ergonomic performance can be improved when instructional support enables students to understand technical procedures and apply them correctly during production and testing stages. Project-based learning media in the form of video tutorials has been shown to strengthen collaborative skills and facilitate procedural understanding, which can support students in performing tasks more accurately and consistently during project implementation (Masruri et al., 2024). In relation to the present findings, the good score for ease of application and removal indicates that procedural clarity and technique standardization remain critical to improve usability, suggesting that more explicit instructional support and technique demonstrations may further strengthen ergonomic outcomes. From a materials perspective, improving durability is essential because reinforcement strategies can alter the mechanical strength of hair structures and influence macroscopic performance, which supports the need to refine attachment and strengthening techniques in applied hair design products (Hallegot et al., 2016).

How Product Based Learning Drives Skill and Innovation

The development process also demonstrates that a structured R&D pathway can support students in producing and evaluating innovative work. Organizing the work through sequential stages enables learners to move from needs analysis and concept design to product development and validation, while documenting decisions and revisions. This supports a learning experience that is closer to real vocational workflow because students engage in making, testing, and improving a tangible output. The expert notes regarding durability and application techniques point to practical challenges that commonly emerge when lightweight frames are scaled to achieve strong visual impact. Improvement can focus on joint strength, surface finishing, and attachment design to enhance ease of application and removal without reducing stability. Iterative refinement is therefore necessary to turn the prototypes into more robust products.

Project-based learning is widely recognized as contributing not only to academic outcomes but also to broader competencies such as life skills, collaboration, and adaptive problem solving. Evidence from a systematic literature network analysis indicates that PjBL contributes to life skills development in biology learning, supporting the idea that project-driven tasks can foster transferable competencies beyond subject mastery (Hizqiyah et al., 2023). Similarly, PjBL implementation has been associated with the development of 21st-century learning skills, including communication, collaboration, creativity, and critical thinking, which are increasingly relevant for vocational graduates facing dynamic professional environments (Kurniawati, 2025). These insights align with the present study, where producing and evaluating tangible hair styling prototypes required students to combine creative design decisions with practical execution and iterative improvement, reflecting a skill set that extends beyond technical production alone. Despite its benefits, PBL implementation often faces practical challenges related to coordination, assessment, and learner readiness, and these issues are frequently reflected in both student and instructor perceptions during program delivery (Moliner et al., 2019). Recent evidence indicates that project-based learning can enhance students' collaborative problem-solving competence, especially when instant feedback is embedded to support timely revision and decision making during project work (Zhou et al., 2025).

Several methodological improvements can strengthen the evidence base in future iterations. A larger number of expert raters, extended wear trials, and more systematic reporting of rating consistency would improve the reliability of evaluation outcomes. Adding longer duration tests may also reveal comfort, fatigue, and durability patterns that are not visible in short trials. Overall, integrating craft materials into hairdressing functions as both a pedagogical innovation and a practical contribution to vocational creativity. The approach encourages students to innovate through alternative materials and structured product making, while also foregrounding the need to meet functional requirements such as comfort, stability, and ease of use. This positioning highlights the potential of the work to link vocational learning with innovation oriented competence development.

Conclusion

This study developed and evaluated three fantasy bun support-frame prototypes made from foam, thin wire, and plastic mesh within a product-based learning approach. Overall, expert validation indicated very good aesthetic quality, and product trials showed very good ergonomic performance, suggesting that the prototypes are feasible for vocational hairdressing practice and can support students in producing visually coherent and usable styling products.

Beyond reporting feasibility, these findings imply that vocational product-making tasks can be positioned as evidence-based learning activities when product quality indicators (e.g., neatness, proportion, harmony) and usability indicators (e.g., comfort, stability, ease of application) are assessed systematically. The results also suggest that integrating material and structural considerations into the project workflow can help connect creative design decisions with measurable performance outcomes, which is relevant for strengthening vocational learning that aligns with professional standards.

Several shortcomings should be acknowledged. The evaluation relied on a limited number of expert raters and short-duration wear tests, which may not fully capture longer-term comfort, fatigue, and structural durability. In addition, assessment evidence was focused on product quality and usability; the study did not include direct measures of students' conceptual understanding or process-skill gains through pre–post testing, and inter-rater reliability was not reported.

Future research should expand the sample of raters and participants, conduct longer and more varied wear trials, and include durability testing under repeated use conditions. Subsequent studies may also incorporate stronger learning-evidence measures, such as pre–post concept checks on relevant material and stability concepts, structured documentation of design rationale, and reliability analysis for expert rubrics. These improvements would strengthen scientific claims about both the product's performance and the learning impact, while supporting broader transferability to other vocational contexts and materials.

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References

Alfiani, S. W., & Sb, N. S. (2024). Developing Guided Reading Guidebook through Leveled Books to Improve Reading Skills of Grade 1 Students. *Jurnal Teknologi Pendidikan*, *26*(2), 538–547. https://doi.org/10.21009/JTP2001.6

Anazifa, R. D., & Djukri, D. (2017). Project- Based Learning and Problem-Based Learning: Are They Effective to Improve Student's Thinking Skills? *Jurnal Pendidikan IPA Indonesia*, *6*(2), 346. https://doi.org/10.15294/jpii.v6i2.11100

Anwar, Y., Nurfadhilah, D., & Tibrani, M. (2024). The Effectiveness of the Project Based Learning (PjBL) Model on the Creative Thinking Skill of Students in the Human Respiration System. *Jurnal Penelitian Pendidikan IPA*, *10*(2), 599–608. https://doi.org/10.29303/jppipa.v10i2.4941

Baldissera, P., & Delprete, C. (2020). From PBL to innovation: a decennial case-study from an HPV student team. *Journal of Engineering, Design and Technology*, *18*(4), 773–786. https://doi.org/10.1108/JEDT-01-2019-0005

Berselli, G., Bilancia, P., & Luzi, L. (2020). Project-based learning of advanced CAD/CAE tools in engineering education. *International Journal on Interactive Design and Manufacturing (IJIDeM)*, *14*(3), 1071–1083. https://doi.org/10.1007/s12008-020-00687-4

Doyan, A., Hadi, D. F., & 'Ardhuha, J. (2023). Effect of PhET Simulation-Assisted Project-Based Learning Model on Students' Creative Thinking Skills in Elasticity Materials. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 3856–3861. https://doi.org/10.29303/jppipa.v9i5.3695

Ganefri, & Hidayat, H. (2015). Production based Learning: An Instructional Design Model in the Context of Vocational Education and Training (VET). *Procedia - Social and Behavioral Sciences*, *204*, 206–211. https://doi.org/10.1016/j.sbspro.2015.08.142

Gomez-del Rio, T., & Rodriguez, J. (2022). Design and assessment of a project-based learning in a laboratory for integrating knowledge and improving engineering design skills. *Education for Chemical Engineers*, *40*, 17–28. https://doi.org/10.1016/j.ece.2022.04.002

Gunawan, G., Sahidu, H., Harjono, A., & Suranti, N. M. Y. (2017). The Effect of Project Based Learning With Virtual Media Assistance on Student's Creativity in Physics. *Jurnal Cakrawala Pendidikan*, 167–179. https://doi.org/10.21831/cp.v36i2.13514

Hallegot, P., Hussler, G., Jeanne-Rose, V., Leroy, F., Pineau, P., & Samain, H. (2016). Discovery of a sol–gel reinforcing the strength of hair structure: mechanisms of action and macroscopic effects on the hair. *Journal of Sol-Gel Science and Technology*, *79*(2), 359–364. https://doi.org/10.1007/s10971-016-3961-z

Hartono, M., Jaya, B. K., Prianka, D., Parung, C. A., & Viviany, V. (2023). Awareness of 3d Body-Scanning and Prospective Update of Indonesian Anthropometry For Virtual Fashion Design. *J@ti Undip: Jurnal Teknik Industri*, *18*(1), 1–11. https://doi.org/10.14710/jati.18.1.1-11

Hayat, M. S., Sumarno, S., Yunus, M., & Nada, N. Q. (2023). STEAM-Based "IPAS Project" Learning as a Study of the Implementation of the Independent Curriculum in Vocational Schools. *Jurnal Penelitian Pendidikan IPA*, *9*(12), 12139–12148. https://doi.org/10.29303/jppipa.v9i12.6005

Hizqiyah, I. Y. N., Nugraha, I., Cartono, C., Ibrahim, Y., Nurlaelah, I., Yanti, M., & Nuraeni, S. (2023). The project-based learning model and its contribution to life skills in biology learning: A systematic literature network analysis. *JPBI (Jurnal Pendidikan*

Biologi Indonesia), *9*(1), 26–35. https://doi.org/10.22219/jpbi.v9i1.22089

Hutapea, J., & Simanjuntak, M. P. (2017). Pengaruh Model Pembelajaran Project Based Learning (PjBL) Terhadap Hasil Belajar Siswa SMA. *INPAFI (Inovasi Pembelajaran Fisika)*, *5*(1). https://doi.org/10.24114/inpafi.v5i1.6597

Kencana, P. C., & Rifa'i, R. (2021). Perbedaan Hasil Belajar Kognitif Siswa Dengan Menggunakan Model Pembelajaran Project Based Learning (PjBL) dan Inkuiri di SMAN 5 Bengkulu Selatan. *PENDIPA Journal of Science Education*, *6*(1), 233–241. https://doi.org/10.33369/pendipa.6.1.233-241

Kurniawati, K. (2025). Developing a Project-Based Learning Module to Improve Vocational Students' Absorption and Skills. *EDUTECH*, *24*(1), 324–333. https://doi.org/10.17509/e.v24i1.79930

Marquez, R., Barrios, N., Vera, R. E., Mendez, M. E., Tolosa, L., Zambrano, F., & Li, Y. (2023). A perspective on the synergistic potential of artificial intelligence and product-based learning strategies in biobased materials education. *Education for Chemical Engineers*, *44*, 164–180. https://doi.org/10.1016/j.ece.2023.05.005

Masruri, M. A., Efendi, A., & Sumaryati, S. (2024). Innovative Project-Based Learning Video Tutorial Media: Development and Its Effect on Students Collaborative Skills. *Jurnal Teknologi Pendidikan*, *26*(3), 926–943. https://doi.org/10.21009/JTP2001.6

Mayasari, T., Kadarohman, A., Rusdiana, D., & Kaniawati, I. (2016). Apakah Model Pembelajaran Problem Based Learning dan Project Based Learning Mampu Melatihkan Keterampilan Abad 21? *Jurnal Pendidikan Fisika Dan Keilmuan (JPFK)*, *2*(1), 48. https://doi.org/10.25273/jpfk.v2i1.24

Moliner, L., Cabedo, L., Royo, M., Gámez-Pérez, J., Lopez-Crespo, P., Segarra, M., & Guraya, T. (2019). On the perceptions of students and professors in the implementation of an inter-university engineering PBL experience. *European Journal of Engineering Education*, *44*(5), 726–744. https://doi.org/10.1080/03043797.2018.1498829

Muslim, M., Ambiyar, A., Setiawan, D., & Putra, R. (2020). Developing project-based learning tools for light vehicle engine maintenance subjects at vocational high school. *Jurnal Pendidikan Vokasi*, *10*(1). https://doi.org/10.21831/jpv.v10i1.29564

Nuraini, N., Asri, I. H., & Fajri, N. (2023). Development of Project Based Learning with STEAM Approach Model Integrated Science Literacy in Improving Student Learning Outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(4), 1632–1640. https://doi.org/10.29303/jppipa.v9i4.2987

Pratiwi, E. A., & Ikhsan, J. (2024). Project Based Learning (PjBL) in Chemistry Learning: Systematic Literature and Bibliometric Review 2015 - 2022. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 343–354. https://doi.org/10.29303/jppipa.v10i6.7017

Rahayu, I., & Sukardi, S. (2021). The Development Of E-Modules Project Based Learning for Students of Computer and Basic Networks at Vocational School. *Journal of Education Technology*, *4*(4), 398. https://doi.org/10.23887/jet.v4i4.29230

Rebia, P. S., Suharno, S., Tamrin, A., & Akhyar, Muh. (2023). Evaluation of Product-Based Education Training Class at Vocational High School using the CIPP Model. *Journal of Curriculum and Teaching*, *12*(3), 135. https://doi.org/10.5430/jct.v12n3p135

Sadrina, S., Mustapha, R., & Ichsan, M. (2018). The evaluation of project-based learning in Malaysia: propose a new framework for polytechnics system. *Jurnal Pendidikan Vokasi*, *8*(2). www.moe.gov.my/

Selasmawati, & Lidyasari, A. T. (2023). Model Pembelajaran Project Based Learning (PjBL) dalam Meningkatkan Kemampuan Berpikir Kritis Sekolah Dasar Guna Mendukung Pembelajaran Abad 21. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1165–1170. https://doi.org/10.29303/jppipa.v9i11.4776

Sucilestari, R., Ramdani, A., Sukarso, A., Susilawati, S., & Rokhmat, J. (2023). Project-Based Learning Supports Students' Creative Thinking in Science Education. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 1038–1044. https://doi.org/10.29303/jppipa.v9i11.5054

Sumarni, W., Wardani, S., & Gupitasari, D. N. (2016). Project Based Learning (PBL) to Improve Psychomotoric Skills: A Classroom Action Research. *Jurnal Pendidikan IPA Indonesia*.

Suyanto, E., Suyatna, A., Destryati, A., & Pratama, A. (2024). Development of ethnoscience-based e-worksheet to stimulate scientific process skills. *Jurnal Ilmiah Pendidikan Fisika Al-Biruni*, *13*(1), 11. https://doi.org/10.24042/jipfalbiruni.v13i1.14408

Yanti, N., Rahmad, M., & Azhar. (2023). Application of PjBL (Project Based Learning) Based Physics Learning Model to Improve Collaboration Skills and Creative Thinking Ability of Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 9973–9978. https://doi.org/10.29303/jppipa.v9i11.5275

Yudiono, H. (2020). Learning process analysis based on industrial products in mechanical practices. *Jurnal Pendidikan Vokasi*, *10*(3). https://doi.org/10.21831/jpv.v10i3.33896

Yulastri, A., Hidayat, H., Ganefri, G., Edya, F., & Islami, S. (2018). Learning outcomes with the application of product based entrepreneurship module in vocational higher education. *Jurnal Pendidikan Vokasi*, *8*(2), 120. https://doi.org/10.21831/jpv.v8i2.15310

Zahirah, B. T. S., Anggreini, A., & Viyanti, V. (2024). The Effect of the STEM Integrated Project-Based

Learning Assisted by Electronic Student Worksheets on Students' Science Process Skills. *Jurnal Penelitian Pendidikan IPA*, *10*(3), 1442–1450. https://doi.org/10.29303/jppipa.v10i3.5461

Zhou, D., Li, H., Sima, Y., Han, Y., & Shi, F. (2025). Improving middle school students' collaborative problem-solving competence in project-based learning through instant feedback in science curriculum. *International Journal of Science Education*, 1–24. https://doi.org/10.1080/09500693.2025.2496427