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FROM DIGITAL FORM TO FINISHED JEWELRY: ADDITIVE MANUFACTURING, CRAFT, AND WEAR

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Abstract: A digitally modeled ornament can retain its intended shape in a rendering yet lose an essential feature during fabrication or finishing. This critical narrative review examines how such downstream requirements influence jewelry design, drawing on fifteen journal articles published between 2020 and 2026. The selected work includes computational and rule-based design cases, scan-fitted settings, polymer and precious-metal processes, craft comparisons, and studies of materials and user preferences. These sources examine different objects: proposed forms, test features, manufactured parts, finished examples, and reported preferences. Their comparison shows that the choice of production route affects more than dimensional feasibility. Support access, polishing, assembly, and setting can require changes to surface, clearance, or proportion that also alter the design's visual and tactile character. Research on successful fabrication provides a firmer basis for these observations than the available evidence on sustained wear, repair, or environmental performance. The article therefore treats finishing conditions as part of form development and proposes a concise way to record design decisions as an object moves from model to use. Comparisons of functionally equivalent finished pieces, followed through wear, would better establish where digital complexity adds value to jewelry.
Keywords: Jewelry design; Additive manufacturing; Design evaluation; Computational design; Craft finishing; Wearability

1 INTRODUCTION

Digital modeling lets a designer resize a ring lattice or rearrange an articulated pendant without remaking the original pattern. Yet a narrow connection may distort during fabrication, a hidden support can be difficult to remove, and polishing may reduce the clearance of a moving joint. These are decisions about the design, not merely faults to correct on the shop floor. Jewelry is viewed close up and repeatedly meets skin, clothing, and the hand; an edge, a setting, and a repairable join can matter as much as the geometry first seen on screen.

Recent studies demonstrate quite different possibilities. Cerrato and colleagues developed bioinspired articulated jewelry through computational design and several additive routes [1]. Hua and colleagues used scans of individual baroque pearls to shape their settings [2]. Metal-processing studies report hollow silver components, integrated links, and platinum pieces made through laser-based processes [3-5]. The outcomes cannot be measured by the same yardstick. A family of digital variants, a setting matched to a particular stone, and a dense metal specimen speak to different stages of making a jewel.

The distinction is often lost when technical performance stands in for finished design quality. A test specimen can show how an alloy responds to processing without revealing how a clasp or a recessed surface will be polished. A convincing prototype may establish form and scale while leaving weight, skin contact, and maintenance unresolved. Comparisons of craft practice and materials point to these later operations, although they seldom follow one object through every stage [6-9]. Reading the evidence together requires attention to what each study actually made or observed.

The concern here is how formal choices change between a digital model and the jewelry eventually handled or worn. Which details remain workable when manufacturing tolerances are known? How do support removal, setting, and polishing affect a motif or articulated structure? And what can be said about the finished object without evidence of longer use? The discussion moves from digital form through fabrication and craft finishing to the design judgments that these stages demand.

2 REVIEW SCOPE AND EVIDENCE APPROACH

This critical narrative review draws on a purposive selection of fifteen journal articles published from 2020 to 2026. Journal and publisher records were searched using combinations of jewelry or jewellery design, 3D printing, additive manufacturing, generative or computational design, precious metals, craft, and sustainable materials. Studies were selected for their relevance to form, fabrication, finishing, and use in jewelry rather than for a single common research method. Seven appeared in Chinese journals and eight in journals published elsewhere. Bibliographic details were checked against publication records, and the key full texts supporting the technical discussion were examined.

The articles examine different kinds of objects. Design projects describe configurable ornament, pearl-specific settings, and rule-derived necklace forms [1,2,10]. Process studies measure features produced in resin or precious metal [3,4,11], while comparisons of polymer ring workflows document the steps between digital inputs and printed outputs [12]. Saharan and Saharan combine FDM examples with a survey of 152 respondents [13]. The remaining work addresses

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teaching, craft comparisons, industrial strategy, manufacturing processes, and material scenarios [5-9,14,15]. A prototype, a density test specimen, and a survey response answer different questions even when each is discussed under the heading of digitally made jewelry.

The analysis follows those differences instead of converting heterogeneous results into a ranking of technologies. It asks what each observation establishes about the form, which later design decision it leaves open, and where findings from another type of study change the interpretation. Because the selection is purposive, the discussion identifies relationships worth examining rather than estimating how frequently they occur across the entire jewelry industry. Proposed consequences for finishing and wear are distinguished from outcomes observed in the source studies.

3 WHAT DIGITAL DESIGN ADDS TO JEWELRY

3.1 Generative Approaches and the Selection of Usable Forms

In the Ecdysis collection, Cerrato and colleagues developed a family of bioinspired forms using computational relationships between overlapping elements and articulated movement [1]. Prototypes were produced through more than one additive process. The interest of this work lies in keeping a recognizable design idea while its geometry changes. For a jewelry designer, that flexibility is useful only insofar as the resulting overlap and movement can be retained in the chosen material and process.

Korkmaz approached variation through manually constructed shape-grammar rules for a snowflake-derived necklace [10]. The rules were not executed by a computational algorithm. Printer size and feature limitations meant that the whole necklace was not produced; a short section was printed to examine the joining detail. Here, the practical question is how a rule-developed pattern behaves at the scale of a manufacturable connection. The partial print documents that encounter without standing in for a completed necklace.

The two projects place formal rules at different points in design. Cerrato's configurable model preserves relationships across variants; Korkmaz's grammar organizes the development of a particular motif [1,10]. Both eventually meet choices about thickness, spacing, and connections. Thickening a delicate branch, for instance, may protect its manufacture while changing the visual rhythm of a snowflake; increasing the gap in an articulated pattern may affect its appearance as well as its motion. The designer must decide which proportions can be adjusted and which carry the idea of the piece. Generating alternatives does not settle that choice.

3.2 Fit, Articulation, and User Preference

An irregular stone presents a different starting point. Hua and colleagues used scans of baroque pearls to guide the geometry of settings for individual specimens [2]. The material's existing contour, not an unrestricted digital outline, directs the design. A setting must accommodate that contour and still allow the stone to be secured without disrupting the intended pearl-metal relationship. Digital fitting is thus an adjustment to a particular material object; the relevant question is whether the fit survives fabrication and assembly.

Movement poses a separate problem. Sun and colleagues discuss the production of complex moving jewelry forms by selective laser melting alongside requirements for supports and polishing [5]. Chen and colleagues demonstrate solder-free hollow and integrated chain-like structures in 925 silver [3]. Making a linked form in one build can reduce the need for later joining, but clearance remains a design dimension after the part is cleaned and polished. A clasp or chain also has to be judged for snagging, edge contact, and changes during use. These are further assessments of a manufactured structure, not additional forms of personalization.

Preference is a third, distinct source of information. Saharan and Saharan presented FDM jewelry examples and surveyed 152 respondents about their interest in such designs [13]. The responses speak to perceived appeal and customization, not to how the objects feel after months of wear. Pearl fitting, articulation, and consumer choice should therefore remain separate in a design evaluation: one concerns accommodation of a singular stone, another the functioning of a mechanism, and the third the response of a potential wearer. Their criteria overlap only when a finished piece is examined in use.

4 FROM PROTOTYPE TO MANUFACTURED PART

4.1 Prototypes, Casting Patterns, and Finished Parts

The phrase '3D-printed jewelry' can refer to a visual prototype, a printed pattern intended for casting, or an object fabricated directly for wear. Each route gives the printed part a different job. Rivera and colleagues compare the production of rings using PLA, PolySmooth, and resin within an input-transformation-output account [12]. Their process comparison helps locate where material choice and subsequent operations enter the workflow. It is especially useful when deciding whether the print is the article being evaluated or an intermediate step toward another material.

A prototype may disclose an awkward proportion or a collision between adjacent features, but its weight and surface response need not resemble those of a precious-metal version. A casting pattern must also survive the requirements of the next process; a directly printed metal component faces final-dimensional and surface inspection. Before describing any route as successful, the designer needs to specify the feature being tested: a visible contour, a stone seat, a mating surface, or a moving clearance. The inspection can then match the purpose of the print.

Tuer and Aiyiti's DLP experiment makes this dependence on purpose and process conditions tangible [11]. With the jewelry casting resin and machine setup they tested, feature accuracy was better at a single-layer exposure time of 9.5 s; build orientation also affected dimensional error. A number recorded for that setup cannot simply be adopted for another resin or printer. More importantly, a modeled clearance or fine detail should be checked against actual output before the pattern is approved. In this setting, calibration protects the intended design rather than serving as a separate technical exercise.

4.2 Precious Metals and Geometry-Dependent Quality

Laser powder bed fusion makes integrated metal forms possible, but alloy behavior and the heat conditions of the build affect the result. Thangamani and colleagues review these dependencies for jewelry applications [9]. Klotz and König report densities above 99.8% in selected specimens made from 950Pt alloys, while actual jewelry parts showed geometry- and support-dependent differences [4]. A qualified test specimen is therefore a useful starting point for a process, not a substitute for examining the particular ornament. The sections, recesses, and attachments in the piece still need their own checks.

Supports illustrate how a structural decision can become a finishing decision. They may be needed for thermal control during laser processing, then have to be removed without damaging thin features or prominent surfaces. Chen and colleagues report a 925 silver hollow ring weighing 4.40 g against a CAD-estimated 12.99 g for the solid counterpart, and document hollow and integrated chain-like structures [3]. The comparison makes a concrete case for reduced material mass in that geometry. At the same time, an enclosed feature must leave enough access for support removal, cleaning, and inspection if it is to become an acceptable piece of jewelry.

Other processes shift the critical moment. Naeimabadi and colleagues review the shrinkage and distortion associated with debinding and sintering in binder jetting [15]. These changes occur during consolidation rather than through the same thermal history as laser fusion. The allowance needed for a clasp opening or a precisely fitted stone seat may therefore differ between routes. Designers who change manufacturing methods may need to revise the original model, not merely substitute one machine for another.

4.3 Finishing Access and Visible Surfaces

Finishing is often shown as the final box in a production diagram, even though its demands may determine the shape from the start. A recessed lattice can obstruct polishing; an enclosed cavity may retain powder; support removal can leave marks where the eye is drawn to a slender junction. Thangamani and colleagues discuss post-processing limitations in metal additive manufacturing, and Liao compares printing with conventional jewelry processes in terms that include surface quality, accuracy, time, and cost [7,9]. Their accounts bring attention to an overlooked feature of complex geometry: access for skilled work is itself a design constraint.

Stone setting gives that constraint a precise form. A seat must follow the stone, but its surrounding metal must also admit the setter's tools and any final polishing. Seen against the fitting study and the manufacturing and craft comparisons [2,7,9], a narrow opening or prominent joint may need to be moved or reshaped before fabrication. Such changes can alter the outline that made the setting attractive in the first place. The useful conversation between modeler, machine operator, setter, and finisher therefore begins while those options are still open.

5 DESIGN TRADE-OFFS ACROSS THE STUDIES

Across the selected studies, technical success becomes meaningful for design only when it is tied to a feature the wearer will see, touch, or use. Table 1 distinguishes reported observations from design questions raised by comparing them. The recurring tension is between geometry that expresses an idea and geometry that remains workable through manufacturing and hand finishing. The studies provide evidence at different stages of that tension; they do not constitute trials of the same finished product.

Table 1 Reported Evidence and the Design Questions It Raises

Evidence and studies	Directly reported material	Design question raised by comparison
Form generation [1,10]	Configurable Ecdysis variants and prototypes; a manually derived snowflake grammar and one printed joining section.	Which motif proportions and connections survive process-specific adjustments?
Scan-fitted setting [2]	Individual baroque pearls were scanned to inform the geometry of their settings.	How do fit, tool access and the visible pearl-metal outline work together after setting?
Polymers and resin [11,12]	Ring-printing workflows; DLP feature accuracy varied with exposure and build orientation.	Which dimensions need checking before a pattern or prototype moves to the next stage?
Precious-metal forms [3-5]	Hollow and linked silver structures; dense platinum test specimens; SLM jewelry applications.	How do enclosed surfaces, support access and moving clearances affect completed quality?
Users and teaching [13,14]	Maker-oriented design tasks; FDM examples and stated preferences from 152 respondents.	How do selection and stated appeal compare with a finished piece in wear?
Craft, strategy, materials [6-9,15]	Craft and process comparisons, manufacturing reviews, design strategy and material scenarios.	Which finishing work and service conditions belong in a comparison of equivalent pieces?

Note: Design questions in the final column are analytical implications of the comparison, not outcomes tested by every cited study.

5.1 Formal Continuity and Manufacturable Detail

An adjustable digital pattern can keep a motif coherent across many variations, but it cannot make every fine connection equally practical. The contrast between computational variants in Ecdysis and the manually derived snowflake necklace makes this distinction visible [1,10]. In the first case, relationships among elements can be altered within a configurable design; in the second, the intended repetition meets a limit at the joining detail. The DLP study adds evidence from another scale: features of the same nominal dimensions can emerge differently when orientation and exposure change [11]. The choice of a final form consequently depends on what happens to its distinctive features under the actual production conditions.

This has a direct consequence for how variants are judged. If a motif relies on fine branching, the design brief needs to identify whether its delicacy or its exact outline matters more when thickness must change. If an articulated family depends on overlap, the priority may instead be preserving the visible sequence of elements while adjusting joint spacing. These are different forms of design compromise, even though both arise from dimensional limits. Recording the rejected variant and the reason for the change would make that compromise available for comparison across processes.

5.2 Lightness, Articulation, and Finishing Access

Lightness and movement can be part of a jewel's aesthetic character, yet both are vulnerable to the geometry required to make them. The hollow silver ring offers a reduction in material mass, while linked structures suggest ways to create movement without separate soldered joints [3]. Neither advantage settles where supports can be reached or how a surface between links will be finished. Evidence from platinum processing and post-processing reviews adds a related concern: part geometry can change the quality obtained from an otherwise successful metal process [4,9]. The relevant design trade-off lies between preserving an open, delicate, or enclosed appearance and leaving enough room for fabrication, inspection, and craft work.

The trade-off becomes sharper when the surface is part of the visual idea. A lattice may look airy in a rendering because its recesses remain deep and dark; making those recesses accessible to a polishing tool could require a different spacing or profile. Similarly, links printed as an integrated chain still need room for movement after surface treatment. Together, these cases and the process reviews move the comparison from the as-printed form to the finished jewel [3,7,9]: how much of the intended lightness and visual depth remains, whether the links still move, and what skilled work is required to achieve both.

5.3 From Appearance to Bodily Use

A fitted pearl and an articulated chain invite different tests once they leave the workshop. The setting must hold a particular irregular stone while retaining the intended outline [2]; the chain must move freely without rough edges compromising comfort [3,5]. Reported interest in customizable FDM pieces provides information about appeal, but it does not answer either physical question [13]. In the reviewed material, evidence is strongest for making forms and assessing specific process results. Longer wear, cleaning, and repair have rarely been followed on the same finished object. This matters especially where a design relies on close contact with skin or a joint's repeated motion: its defining quality may be precisely what a static prototype cannot show.

The effects run back toward the first sketch. A cavity that cannot be cleaned may need an opening; polishing a joint may demand more separation; a setting that resists tool access may require a new profile. Each revision changes more than a production instruction. It can affect how a motif reads, how weight is distributed, or how the piece meets the body. For jewelry made through digital processes, the workable design is the form that survives those negotiations, with its intended visual and functional relationships still legible in the finished object.

6 CRAFT, MEANING, AND MATERIAL CHOICES

6.1 Hand Finishing and the Expression of Form

The movement from printed part to jewelry still calls for skilled decisions. A scan may define a pearl's contours, and a machine may reproduce the chosen outline, but a setter must judge how the metal meets the stone and how its worked surface appears beside it. Liao's comparison of printing and conventional processes draws attention to the practical mix of surface quality, production time, and cost [7]. Omitting a mold may suit a single commission; using established tooling may be reasonable for repeated pieces. These are choices made for a particular design and finishing standard, not a general contest between handwork and digital manufacture.

A related question arises in jewelry education. Li and colleagues describe maker-oriented teaching in which students design and produce integrated pieces using 3D printing [14]. The educational value for the present discussion lies in the opportunity to compare a rendering with a made object and to record what changed between them. A student who widens a join, moves a support, or revises a surface after inspection can explain the decision in design terms. That

evidence is different from a claim about industrial productivity, but it makes the relation between form and fabrication visible to a learner.

The shape alone does not carry all the meaning of a piece. Li and Sun consider innovation through jewelry design and industry strategy [6], while the Ecdysis and snowflake projects offer examples in which a recognizable motif organizes the ornament [1,10]. A scaled-up branch may weaken the delicacy of a snowflake; a stiffer arrangement of overlapping elements may alter the association with movement. Those judgments depend on the intended image and the finished effect, not a machine's accuracy reading. Craft work can preserve, modify, or sometimes clarify that effect when the original geometry proves difficult to finish.

6.2 Material Use and Environmental Comparison

Using less metal in a component is a tangible design result; demonstrating lower environmental impact is a different task. The hollow 925 silver ring is lighter than the solid form used for its CAD comparison [3]. The figures, however, describe that geometry and do not account for unsuccessful builds, support material, electricity, polishing, or maintenance. Reviews of metal processes describe sources of loss and possible efficiencies [9,15]. They cannot supply a single environmental verdict for jewelry made by every route. Any such assessment needs a functionally comparable finished article and a defined scope for the resources it uses.

Tenuta and colleagues discuss sustainable-material scenarios from a design perspective [8]. Their proposals invite questions about sourcing, repair, durability, and what happens to a piece at the end of its use. These questions are particularly important in jewelry, where a temporary accessory and a long-kept, repairable object may perform very different roles. Comparing their material quantities alone would conceal that difference. For an environmental claim to inform a design choice, it must state the intended function, service life, and the processes included in the comparison.

Material decisions also shape the sensory life of the object. A texture arranged to catch light becomes a surface against skin; a hollow form changes the balance of a ring in the hand; a polished joint may look smoother while losing some clearance for movement. Such effects explain why finishing cannot be considered only a remedy for manufacturing defects. It helps determine the visible and tactile character that a jewelry design finally acquires.

7 RECORDING DESIGN DECISIONS

The comparison suggests a straightforward way to document the decisions that connect model and finished jewel. Table 2 organizes the record around an initial form, the chosen production route, finishing and assembly, and subsequent use. The point is to retain the reason for a change alongside the result: why a gap was enlarged, which surface was left accessible, or why a particular setting profile was rejected. Movement between stages is expected. A problem found during polishing can return the work to the model before another print is approved.

Table 2 A Suggested Record of Design Decisions and Their Consequences

Design stage	Information to retain	Design decision brought into view
Initial form	Motif, wearer, contact points, moving features, stone fit and critical dimensions.	Which visual or functional relationships must survive later adjustments.
Build and transfer	Role of print, material and machine, orientation, tolerances, iterations and rejects.	Where the modeled feature required calibration or a change of route.
Finishing and assembly	Support removal, cleaning, polishing, tool access, setting, clearances and manual time.	How craft operations affected the surface, fit and movement.
Use and upkeep	Defined wear observations, surface and joint checks, repair options and resource boundaries.	How the completed piece performs under the stated conditions of use.

Note: This proposed documentation aid has not been validated as an acceptance standard.

For the scan-fitted pearl setting, the record would begin with the stone's outline and the intended pearl-metal relation, then note adjustments required for fitting and securing it [2]. For an integrated silver chain, it would capture clearances, support access, and movement after finishing [3]. A polymer ring printed only to examine appearance would be identified as a prototype, with its later material and finishing route still to be established [12]. What matters is not the amount of documentation but whether a subsequent reader can see why the design changed.

Measurements and photographs should be linked to the question that prompted them. Dimensions taken before and after polishing help assess clearance; notes on the feel of an interior edge can guide a surface revision; records of rejected builds and manual finishing time make a process comparison more informative. The designer may also document how the motif reads after a necessary increase in thickness or a change in material. Such observations retain an account of aesthetic judgment without reducing it to a single score.

8 RESEARCH THAT FOLLOWS THE OBJECT

A useful test of competing production routes would start with the same jewelry brief and assess comparable finished pieces. Directly printed metal, casting from printed patterns, and an appropriate conventional route could be examined with matched functional requirements and an agreed finishing standard. The record should include build failures, dimensional changes, support removal, setting and polishing time, and the quality of accepted pieces. One-off

commissions and production batches would need separate cost analyses. This approach would show when a complex digital form earns its place in the finished object and when the operations required to complete it offset the apparent manufacturing advantage.

A second study design would follow finished jewelry through use. A ring interior, an articulated link, or a narrow setting could be inspected at defined intervals for surface change, clearance, security, and snagging, alongside wearer accounts of comfort and appearance. This would move beyond the preference information available from FDM survey work [13]. It would also test the assumption implicit in many process demonstrations: that a feature which leaves fabrication intact continues to perform in contact with the body.

Both comparisons would benefit from recording abandoned variants as well as completed designs. In studies of rule-based or computational form generation [1,10], the reasons for rejecting a variant could show where a motif lost clarity or its joints became impractical. Environmental assessments would require additional records of material recovery, energy, repair, and service life, with product function and system boundaries fixed in advance [8]. The aim is not a universal score for jewelry, but evidence that connects a particular design choice to the finished piece and the conditions of its use.

9 CONCLUSION

The hardest design decisions often appear after a printable form has been chosen. An enclosed surface may give a ring its lightness yet limit access for cleaning and polishing; the gap that permits an integrated link to move can narrow during finishing; a pearl setting that follows an irregular stone must also leave room for securing it. Across the reviewed studies, these pressures explain why technical results and design outcomes cannot simply be treated as equivalents. Manufacturing conditions and skilled finishing affect the proportions, surfaces, and motion through which a piece acquires its character.

The evidence is much less developed once a jewel enters regular use. Process tests and prototypes describe particular stages of making, while comfort, repair, and changes during wear require observation of completed objects. Comparing equivalent finished pieces, and recording the revisions made between model and object, would clarify when digital variation is worth the work it demands. In jewelry, fabrication and finishing do not merely implement a finished idea: their constraints help determine what that idea becomes.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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