PRINCIPLES OF ARISTOTLE'S POIESIS AS A FOUNDATION FOR HUMAN-CENTERED ENGINEERING DESIGN

An Undergraduate Research Scholars Thesis

by

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ABSTRACT

Aristotle's Poiesis as a Conceptual Framework for Uniting Human-Centered Design with Traditional Engineering Methods.
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In order to improve design methodology and better utilize human-centered design (HCD) approaches, there is a need for an intellectual foundation to reconcile HCD with traditional design approaches. A method from Aristotle, called Poiesis, provides a useful basis for this while helping to relate engineering design to a general discipline of design. In this paper, we explain what Poiesis is in an engineering design context, and examine the similarities between current methods and this ancient approach. Current methodology is similar to different parts of Poiesis, but we propose that it can be improved by combining different existing methods using Poiesis as a framework for a more comprehensive, holistic approach.

CHAPTER I

INTRODUCTION

Human-centered design (HCD), which is sometimes referred to as user-centered design or emotional design, differs from traditional engineering design methods by making the user's values, emotions, and needs central to the design process [1]. These considerations are an important source of value for customers and users of designed artifacts [2]. Consequently, there is growing interest in HCD methods and how they relate to and can be combined with established design methodology.

Modern engineering design is founded upon a systematic approach in which designers follow an explicit process to define an artifact or system that meets an identified need. Numerous authors prescribe engineering design processes in the literature, e.g., Pahl and Beitz [3], Ulrich and Eppinger [4], Cross [5], and Otto and Wood [6]. Under these approaches, designers typically would consider user needs during the early phases of design and carry forward any conclusions they draw from this analysis (e.g., in the form of design requirements). However, the way in which existing engineering design methods deal with user considerations is relatively limited. Methods for HCD are a topic of ongoing research. These approaches instruct designers to understand the user more holistically—such as in terms of their aspirations, fears, and ideologies, in addition to their physical needs. Under HCD, designers then translate these values of the user into aspects of the design, e.g. Boatwright and Cagan [7], Jordan [8], and Norman and Draper [1]. Additional surveys of HCD can be found in Vredenburg [9] and Boztepe [2]. However, HCD methods alone are not an adequate replacement for engineering design methods. Methods for

HCD tend to focus on the human-centered parts of the design process without establishing clearly how they fit into a more comprehensive design framework. Consequently, they have limitations addressing technical and non-human aspects of engineering design.

Engineering designers and the users of engineered products alike would benefit from a holistic approach to design that has the strengths of both established engineering design methods and HCD methods. However, it is unlikely one can achieve this through an arbitrary combination of existing methods. In this paper we clarify and strengthen the connections between engineering design and HCD by viewing them each as specialized realizations of a general method for designing that was described in one of the earliest texts on design: Aristotle's Poetics [10]. This method will be referred to as *Poiesis*, the original Greek name given to it by Aristotle.

In this research, we will answer several fundamental questions about *Poiesis*. First, *what is Poiesis within the context of engineering design?* Second, *how does existing design methodology relate to Poiesis?* Specifically, we focus on which elements of *Poiesis* are present in particular HCD and traditional engineering design methods and seek to understand how each of these approaches fits into a framework for design based on *Poiesis.* Third, *what are some areas of weakness and potential improvement in the examined design methodology based on the level of agreement with the principles of Poiesis?* To answer these questions, we perform a detailed conceptual analysis of the methods under consideration based on the published literature. The result is a deeper understanding of all the methods as well as guidance on identifying new design methods that better integrate the traditional and human-centered perspectives on engineering design. Detailed validation of new design methods is a topic for future work.

The next section of this paper addresses the first of these questions, with an interpretation of *Poiesis* in the context of engineering design. Section 3 is a qualitative semantic analysis of some traditional and HCD engineering design methods from the perspective of *Poiesis*. In section 4, we explain our conclusions and recommendations based on this analysis in order to answer the second and third questions. Section 5 summarizes the research and its outcome.

CHAPTER II

PROBLEM

Context

In the fourth century B.C., Aristotle wrote Poetics, in which he deconstructed tragedy and epic poetry for the purpose of determining how they were and should be created [10]. Moreover, it is a study about design and establishes design principles. Although Poetics may at first seem irrelevant to the design of technical artifacts, a closer examination of the text, the original meanings of its words, and the context in which it was written reveals that Aristotle's design principles apply beyond poetry. The word "poetics" actually derives from the Greek word "*Poiesis*[1]", which means "making things," or the "science of production."

Additionally, the concept of art that *Poiesis* addresses comes from the word *Techne,* which describes the transaction between an intelligent being and the intelligible world and is more closely related to our word "technology." [11] The ancient Greeks made great strides in engineering and technology, including significant advances in the areas of naval, structural, and civil engineering. They developed technology that remains in use today, such as levers and pulleys [12]. However, in Aristotle's time, engineering was not considered separate from *Techne* which is essentially craftsmanship and also encompassed artists, sculptors, and poets [11]. These craftsmen all sought to harness the natural world and its principles to create artifacts. This contrasted with the Greek notion of *episteme*, which was pure scientific knowledge, such as mathematics and astronomy [13]. Tragedy and epic poetry served as example mediums of

[1] *Poiesis* will be used here to refer to the principles and theoretical framework for design laid out in the Poetics, to avoid confusion with the text itself.

Poiesis, common during Aristotle's time, to which he chose to apply his theory [14]. Prior authors have interpreted *Poiesis* as being applicable to other creative outlets, such as visual art and music [15], [16]. We propose that principles from *Poiesis* are also relevant to engineering design and provide an intellectual foundation useful for unifying traditional engineering design methods with HCD.

Since the times of Greek antiquity, and especially with the advent of the industrial revolution, technology and art split from *techne* into distinct areas. Technology, and engineering came to be more closely aligned with scientific knowledge. However, engineering design should ideally contain an awareness of both the technical and the empathic, "humanistic" aspects of an artifact [17]. The Poetics has been recognized as having significant direct and indirect influence on our current ideas about the design of useful objects [18]. The context in which Aristotle wrote the Poetics makes it highly relevant to the goal of uniting traditional engineering design methods and HCD methods.

Basis of Poiesis

Poiesis is not the final designed product but the art of creating it. Aristotle identified *Poiesis* as being fundamentally concerned with "*Mimesis"*, or imitation of action. This refers to the rationalist approach man employs when he imitates nature's creative forces. *Poiesis* can be identified based on four constituents that define the context it takes place in: *matter*, *agent*, *goal*, and *form*. The fundamental nature of *Poiesis* is the same for all types of design and creation but *matter*, *agent*, *goal,* and *form* will vary depending on the context it is being applied to (i.e.

Table 1. ELEMENTS OF POIESIS AND HOW THEY APPLY TO ENGINEERING DESIGN.

Element of Poiesis	*In poetry*	*In engineering design*
Plot (Purpose)	Story of poem, beginning and end of it	Purpose and context of design (i.e. contextual needs, functional model, solution neutral problem statement)
Character (Quality)	Qualities that poet instills in characters and poem	How to realize purpose (i.e. concept generation, concept evaluation)
Thought (Analysis)	Discursive thought about poem and themes present in it	Analysis of design (failure modes, material/manufacturing selection, cost)
Diction (Communication)	Words used for delivery of poem to audience	Style, user value/emotional benefit
Melody (Aesthetics)	Songs and artistic value in poem	Aesthetics and artistic value of design
Spectacle (Embellishment)	Non-subtle evoking of emotion through something superficial (i.e. special effects)	Superficial adornment, or "skin" of design

tragedy, music, or a consumer product). In all contexts, design should deliver to the audience pleasure, or emotional value, of an appropriate type for the function and context [19]

There are advantages to recognizing the connections between *Poiesis* and the engineering design process. First, *Poiesis* offers a framework that integrates aspects of HCD into the overall design process. Like HCD, *Poiesis* is fundamentally concerned with the value that artifacts bring to the user. The basic idea of *Poiesis* is the creation of something that delivers specific emotions to an audience [20]. Additionally, the recognition of *Poiesis* as applicable to engineering design will also help to establish engineering design as just one realization of an overarching discipline of design. By linking engineering design to a general discipline of design, further design research can proceed as a more coordinated effort between disciplines like architecture and management [21]. *Poiesis* also provides an interesting theoretical framework for design, identifying the different elements, or stages, of design with their relative importance. It provides a description of how these elements flow and the mental state required of designers at each. A critical analysis of current design methods as they compare to *Poiesis* may indicate weaknesses and draw attention to potential areas of improvement in engineering design methods and research [22].

Elements and overall flow

Aristotle recognized six different elements of how *Poiesis* takes place. These are *plot*, *character*, *thought*, *diction*, *melody*, and *spectacle*. The underlying four constituents previously mentioned (matter, agent, goal, and form) are "what" *Poiesis* is—or its context—and these elements are the stages of "how" it happens. These elements progress from the most fundamental aspects of a design to the more superficial, and less important ones [23]. At the same time they mirror the process by which a designer must think about the construction of the product. These elements are described in the context of poetry and engineering design in **Table 1**.

These elements are not a linear process flowing strictly from one to the next but instead move in an iterative spiral from the designer to the user as the designed artifact becomes more developed. These elements and their flow are based on observations of the stages of the design process made by Aristotle. The specific principles laid out for each of these, which are summarized in Table 2, describe the best practice for each element of *Poiesis*. In this manner, *Poiesis* is both descriptive and prescriptive in nature [24]. An illustrative example of how these elements proceed is shown in Figure 1. This is not a definitive model; it is our attempt to interpret *Poiesis* as a design framework represented, like many design methods, as a process diagram.

Most design methods are modeled around actions of the designer. For example, Pahl and Beitz provide phases and steps organized based on actions from the designer [3]. A survey of design methods by Roschuni found that design methods are based largely on similar activities [25]. It is important to note that rather than being modeled around actions, *Poiesis* is based on the level of development of the design itself. This of course should run parallel to action-based methods, which dominate the design community today, but it is a significant distinction. Our flow diagram places these different elements of the design on a chart describing the way the designer deals with these mentally.

Table 2. THE 24 PRINCIPLES IDENTIFIED IN *POIESIS* WITH DESCRIPTIONS IN THE CONTEXT OF ENGINEERING DESIGN.

Principles	*Description*
Plot (Purpose)	
1. User/Context understanding	The purpose should include an understanding of the context of the design and user.
2. Central purpose-ethical/makes sense	The central purpose of the design should make sense and be ethical.
3. Determinate and necessary	All parts of the purpose are determinate and necessary.
4. Forget preconceptions (avoid fixation), fit design into reality	The designer must forget preconceptions about the design problem and draw comparisons between mental constructs and the world.
Character (Quality)	
5. Good	The designer should judge generated concepts to be good.
6. Propriety (meets technical requirements)	The concept should conform to standards, proper behavior for the design, and meet requirements.
7. True to life (feasible)	The concept should be reasonably capable of being achieved.
8. Consistent with purpose	The concept should be consistent with the *Plot*.
9. Allow for designer preference but provide structure for evaluating ideas	The designer must exercise creativity and intuition in a structured manner in which they can assemble ideas into concepts.
Thought (Analysis)	
10. Balance/maintain artistic quality of design with analysis	The discursive analysis should not eliminate or obstruct the artistic aspects of the design, but be balanced with this.
11. Address mathematical analysis and make needed assumptions	The designer should use mathematical analysis and be able to utilize engineering assumptions at this stage.
Diction (Communication)	
12. User's perspective for determining Diction	The designer should take the audience's perspective for determining the *Diction*.
13. "Clear without being mean"-easy to understand but unique	The designer should avoid both lofty and mean deliveries, but instead should aim for ordinary language that can be easily understood by the user. Something out of the ordinary should make the design stand out for the user though.
14. Connect properties to user's emotional response	The designer must use features of the design to relate their message to the user.
Melody (Aesthetics)	
15. Artistic value-can stand alone as work of art	The design should have intrinsic artistic value and be able to stand on its own as a work of art.
16. "Probable impossibilities"-make unlikely seem natural	The designer should seek to make the novel or eccentric seem fitting.
17. Identify/structure abstract value of aesthetics	The designer should be able to assemble and organize aspects of the design to achieve abstract artistic value.
Spectacle (Embellishment)	
18. Evoke emotion in direct, non-artistic way	The superficial ornamentation of the design should evoke emotion.
19. Analytical logic to address product anew, refine and make "skin"	The designer should be able to "forget" the underlying design and look at it from a fresh perspective to refine and embellish it.

Table 2. CONTINUED.

Principles	*Description*
General process	
20. Same general order of elements	The process should move generally in the same order of elements found in *Poiesis*.
21. Same relative importance of elements	The process should recognize that the stages progress from the most important to least important.
22. Spiral process-iterative and cyclical	The process should recognize that design is not linear but iterative and cyclical.
23. Communication between designer and user through design	The process should acknowledge the importance and nature of communication between the designer and user through the design.
24. Emphasize needs/desires of user-deliver function and pleasure	The process should aim to deliver emotional value to the user while meeting functional needs as well.

The process is laid out in a spiral-pattern, progressing from the designer out to the user. It passes through four different quadrants that convey the mental state of problem solving for the elements in them. *Poiesis* is fundamentally imitation of action in the sense of how nature acts [26]; these quadrants can be thought of as the type of rational creative forces evident in nature, which are being imitated by the designer. There are two axes that divide these quadrants. The horizontal axis spans *chaotic* and *structured*. The vertical axis spans *concrete* and *abstract*. The four quadrants of problem solving are *reflection*, *imagining*, *analyzing*, and *blurring*. The names of these quadrants are drawn from Voyer [27]. This quadrant system is also similar to the Gregorc 4 quadrants of learning styles [28] and a representation of design problem solving identified by Souchkov [29]. These quadrants are summarized in Table 3 with multiple expressions for the quadrants and the axes used to clarify their meaning. The elements for each quadrant are also listed.

As can be seen in the diagram, the first three elements flow forward to the next element as well as back to the designer [30]. This creates an iterative process by which the more fundamental constructs inform the designer and then in turn influence the design. The last three elements flow forward as well as out to the user. In the case of the final element, *spectacle*, this is the final delivery of the entire product. For the others, this simply indicates that these elements are ultimately part of the communication of the product to the user, which has also been identified by Crilly et al. [31]. Solid lines are used to indicate direct flow in the process and dotted lines show an implied influence in the process.

Table 3. THE QUADRANTS USED TO ARRANGE POIESIS WITH MULTIPLE EXPRESSIONS FOR THE QUADRANTS AND AXES; THE ELEMENTS ASSOCIATED WITH EACH OF THESE.

Elements in Poiesis	*Quadrants from Voyer*	*Quadrants from Souchkov*	*Axes from Gregorc/Souchkov*
Plot, Thought, Catharsis	Blurring	Direct Jump	Random/Chaotic and Concrete/Specific
Plot, Diction	Reflection	Analogy	Random/Chaotic and Abstract
Character, Melody	Imagining	Abstract Patterns	Sequential/Structured and Abstract
Thought, Catharsis	Analyzing	Analytical Logic	Sequential/Structured and Concrete/Specific

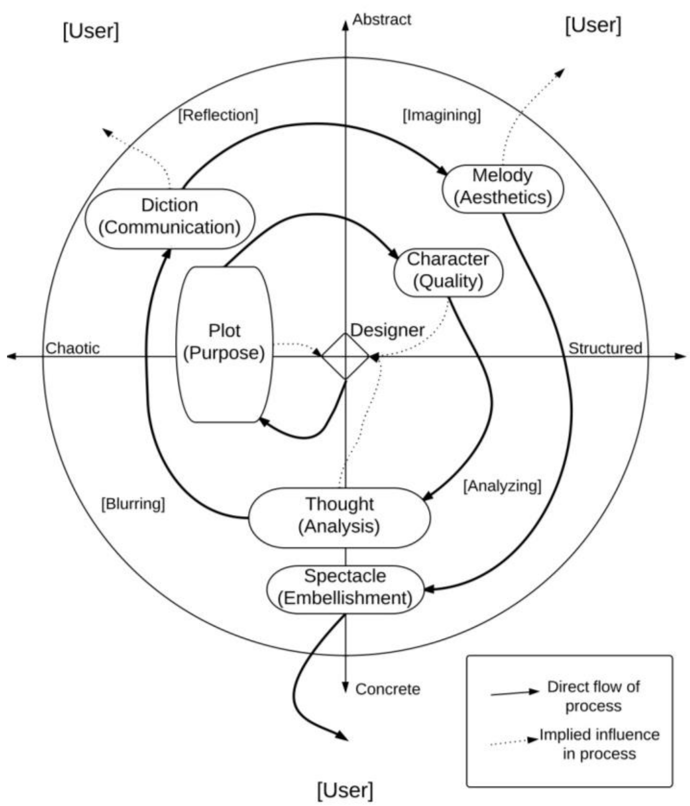

Figure 1. THE FLOW OF ELEMENTS IN POIESIS, PROCEEDING FROM THE DESIGNER TO THE USER.

We established twenty-four principles, as shown previously in Table 2, to describe each of the six elements and the nature of the overall method of *Poiesis*. This allowed us to perform a semantic comparison of these principles of *Poiesis* with current design methods. Some of these principles have been specifically identified as important in engineering design, such as principle 16, which calls for probable impossibilities, or designing things such that the novel or eccentric seems fitting or intuitive [31]. Pugh has called for the use of design metaphors that are familiar with users and will not create confusion. This is a recognition of the benefits of principle 13—being “clear without being mean”, which means using language that the user understands but is still subtle, like that of the metaphorical desktop layout in software design [32].

CHAPTER III

ANALYSIS OF DESIGN METHODS FROM A POIESIS-BASED PERSPECTIVE

In order to determine the similarity between *Poiesis* and current design methodology, five representative methods were selected for comparison to the twenty-four principles from *Poiesis*. In doing this, we sought to see which principles are used in each method. We did not necessarily expect any of the methods to exhibit all of the principles but were interested in which principles were present in the methods. We chose three more traditional engineering design methods that are widely cited including Pahl and Beitz [3], Ulrich and Eppinger [4], and Cross [5]. We also selected two human-centered design (HCD) methods. These were Jordan [8], which is widely cited, and Boatwright and Cagan [7], which is a more recent text on HCD. It is expected that HCD methods contain principles of *Poiesis* that deal specifically with delivering emotional value to an audience. Table 4 contains the results of this comparison. A more detailed overview of the analysis and results is provided in the Appendix.

As an example of how we performed this analysis, we turn to Pahl and Beitz [3] at the stage of defining the *plot* (or purpose) of a design (principles 1-4). This method fails to include the first principle of understanding the user or context. Although Pahl and Beitz acknowledge the significance of marketing analysis, it is not a tightly integrated part of their method. Instead of providing engineers guidance for understanding the user, Pahl and Beitz assume that the relevant results will be provided to design engineers by “special planning departments of companies”. The method does contain the other three principles for *plot*. It refers to the “crux of [the] task” which is akin to the central purpose, and it discusses how the designer must "abstract" this to a level that makes sense and allows the designer to have greater "influence and responsibility" of the problem allowing for opportunities such as "environmental protection." The third principle of the *plot* being determinate and necessary is accounted for in the function structures the method uses and the analysis of whether the functions are logically "necessary." The fourth principle is found in the discussion of "[ignoring] the incidental" thereby forgetting preconceptions. The use of analogies in the method, while not directly included as a principle in our survey, further reinforces the connection with this fourth principle, which accounts for the designer's mental state.

Pahl and Beitz

Pahl and Beitz present a systematic design method consisting of four main phases: (1) planning and clarification, (2) conceptual design, (3) embodiment design, and (4) detail design [3]. Each phase consists of several tasks that designers must complete. These are action-based categories, in contrast with the elements of *Poiesis*, which are based on artifact attributes. The overall order of elements is similar to *Poiesis*.

The method for engineering design put forth by Pahl and Beitz is most similar to the design principles of *Poiesis* in the earliest stages, or elements, of *plot* and *character*. It is lacking in the principle of understanding the user and context at the stage of plot but contains the three other principles of plot, as discussed earlier. It is completely aligned with the determining and evaluating of *character* of the design. Pahl and Beitz note that, "good ideas are always scrutinized" and that only ideas that meet specification and are realizable should be pursued. The function structure relates character to purpose and the approach allows for designer intuition while providing structure for this. After this point though, it is less similar. Although the general order of elements is the same, it lacks the other principles of the general process and only

Table 4. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH DESIGN METHODS. AN 'X' MEANS THAT THE PRINCIPLE WAS FOUND IN THE TEXT OF THE METHOD.

Principles	*Pahl & Beitz*	*Ulrich & Eppinger*	*Cross*	*Jordan*	*Boatwright & Cagan*
Plot (Purpose)					
1. User/Context understanding		x	x	x	x
2. Central purpose-ethical/makes sense	x		x		
3. Determinate and necessary	x	x	x		
4. Forget preconceptions (avoid fixation), fit design into reality	x	x	x		
Character (Quality)					
5. Good	x	x		x	
6. Propriety (meets technical requirements)	x	x	x		
7. True to life (feasible)	x		x		
8. Consistent with purpose	x	x	x	x	x
9. Allow for designer preference but provide structure for evaluating ideas	x	x	x	x	x
Thought (Analysis)					
10. Balance/maintain artistic quality of design with analysis					
11. Address mathematical analysis and make needed assumptions	x		x		
Diction (Communication)					
12. User's perspective for determining Diction		x	x	x	x
13. "Clear without being mean"-easy to understand but unique		x		x	x
14. Connect properties to user's emotional response		x	x	x	x
Melody (Aesthetics)					
15. Artistic value-can stand alone as work of art				x	x
16. "Probable impossibilities"-make unlikely seem natural				x	
17. Identify/structure abstract value of aesthetics				x	x
Spectacle (Embellishment)					
18. Evoke emotion in direct, non-artistic way			x	x	x
19. Analytical logic to address product anew, refine and make "skin"			x	x	x
General process					
20. Same general order of elements	x	x	x	x	x
21. Same relative importance of elements					
22. Spiral process-iterative and cyclical			x		
23. Communication between designer and user through design			x	x	x
24. Emphasize needs/desires of user-deliver function and pleasure			x	x	x

possesses one other principle: that of addressing mathematical analysis and making needed assumptions through modeling and calculations at the embodiment design stage. The artistic balance in the analysis is not present though. It fails to address at all the principles at the stages of *diction*, *melody*, and *spectacle* focusing instead on reaching a definitive layout and documentation of the design. The refinement of the artifact at the three later stages of *Poiesis* is unaccounted for.

Ulrich and Eppinger

Ulrich and Eppinger present a more modern but still traditional design method that includes some consideration of the customer's needs in addition to more traditional steps, such as determining specifications and selecting concepts [4]. It includes aspects of marketing and manufacturing in its portrayal of the design process.

Ulrich and Eppinger's approach to design has a strong similarity to *Poiesis* in *plot*, where it has three out of four principles—lacking only that of the central purpose that is ethical and makes sense; *diction*, where it has three out of three principles, and *character*, where it has four out of five principles. Ulrich and Eppinger do not account for any principles related to *thought, melody*, or *spectacle* but they do maintain the same general order of elements.

Cross

Cross [5] is a traditional engineering design method because of what it sets out to do, but it has a strikingly different conception of design as compared to Pahl and Beitz [3] and Ulrich and Eppinger [4]. This is possibly because of the author's background in architecture design.

Similarly though, it begins with objectives and proceeds to define functions, requirements and determine and evaluate concepts. It recognizes the iterative nature of design between a high level understanding and sub-problems and sub-solutions.

Cross is one of the more balanced methods examined. Of the methods here, it is the one most like the general process of *Poiesis*, lacking only the same relative importance of elements. It has a similarly ordered iterative, cyclical process and recognizes the need to communicate with the user and deliver function and pleasure through the design. It fully accounts for the principles of *plot* very explicitly by clarifying objectives for the design with a thorough objective tree and brief. It meets most of the principles of *character* through a well-reasoned adherence to the objectives of the design laid out, and some of those for *thought* and *diction* through mathematical analysis and recognition of communication with the user. It has no recognition of principles for *melody*, but fully includes *spectacle's* principles. It recognizes the refinement of the outer skin of the design and the surface appeal but lacks instruction to focus on aesthetics for a deeper and purely artistic end.

Jordan

Jordan presents a human-centered approach to design that includes an understanding of human factors and usability but goes a step further [8]. In having a holistic view of the user, it is essential to also consider the user's values and emotions. Jordan categorizes how people should be understood into aspects of the user profile such as their physical and ideological characteristics. By designing for these areas, a designer can bring the user joy, in addition to whatever functions they are seeking to accomplish.

This HCD method from Jordan is good at moving from experiential to formal properties, or from a more general "black box" emotionally functional view of a design to more specific means of communication. It has the strongest resemblance of *Poiesis* at the later stages of design, fully accounting for the elements of *diction, melody,* and *spectacle*. Each of these principles is accounted for through either explicit recognition—such as calling for the artifact to be able to stand alone as an "*Objet d'art*", or through techniques like systematically linking emotional responses to six categories of product characteristics. It also addresses a few of the principles of the general process with a similar understanding of the overall process and what it should deliver to the user. Furthermore, it accounts for some of the principles of character through how it processes specifications to generate ideas. With the exception of the initial understanding of the user, it neglects the *plot* and also the principles of *thought*. Jordan focuses on the delivery of emotion to the user but seems to assume the purpose and technical requirements are a given. Although there is guidance for aspects of the design that excite the user, there is a lack of guidance as to how to meet basic functional expectations about the design.

Boatwright and Cagan

Boatwright and Cagan primarily attempt to persuade and demonstrate the importance of considering emotional fulfillment in designing products through case studies and research into the profitability of this emphasis [7]. There is also a straightforward method for how to incorporate this awareness of a design's emotional value and achieve the desired response in users. This method involves identifying the emotions that are appropriate for the product, developing a strategy for the product or product family, and implementing this strategy through targeted features.

To be fair in this assessment of the level of accordance of Boatwright and Cagan with *Poiesis*, it should be noted that the authors recognize and readily admit that what they are presenting is not a comprehensive design method. Instead, it is a supplement to adapt to current practices, which do not include the emotional value in design. However, it is not clearly detailed where this method fits in the overall design process. Evaluated as a stand-alone method, it addresses the later stages of design better, based on its likeness to *Poiesis*. It accounts for the user understanding, maintaining a consistency with the purpose, and providing structure while allowing for designer preference in the element of determining quality of the design. Otherwise, it lacks all the elements of *plot*, *character*, and *thought*. Similarly to Jordan there is no guidance for meeting functional requirements of the design. It doesn't note the role of "probable impossibilities," which make the unlikely seem natural, in the aesthetics element. Otherwise it possesses all the elements of *diction*, *melody*, and *spectacle* through design of shape grammars, touchpoints, customer feedback, and general recognition of the importance of including aesthetics consideration while refining the artifact. The general process is similar to *Poiesis* except for the lack of an iterative, cyclical definition of design and the relative importance of elements.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Similarity of traditional and HCD methods to *Poiesis*

In comparing the similarity between the traditional and human-centered design (HCD) methods and the principles of *Poiesis*, some interesting trends can be seen. The twenty-four principles found in *Poiesis* are present in varying degrees across the five selected methods. Only two principles are not accounted for: principle 10: balancing and maintaining artistic quality of a design with the analysis, and principle 21: the relative importance of elements. This seems to indicate that the ideas of *Poiesis* are present in current engineering design methodology. As *Poiesis* is a general approach to design, this implies that the principles in it are generalized principles of design that apply to various disciplines of design such as architecture, poetry, and engineering design.

No design method examined was in complete agreement with the ideas of *Poiesis*—each method was found to be somewhere in the middle of this spectrum. Each of the methods examined had between ten and seventeen principles, out of the twenty-four surveyed, in common with *Poiesis*. The traditional methods tended to have more similarity at the earlier stages while the HCD methods had more similarity in the later stages.

Recommendations for merging traditional and HCD methods

This research provides some insight as to how HCD methods should be combined with traditional methods. Rather than arbitrarily combining HCD and traditional methods, *Poiesis* can be used as a framework for fitting the methods into the overall design process. Furthermore, based on the varying degrees of similarity, a hybrid method can be made that achieves better agreement with *Poiesis* by drawing from several different methods. For example, a hybrid, *Poiesis*-based approach can be constructed with the methods enhancing *plot* from Cross [5], *character* from Pahl and Beitz [3], and *diction*, *melody*, and *spectacle* from Jordan [8]. Additionally, the general process from Cross [5] comes close to *Poiesis* and consideration of the relative importance of elements could be directly added from *Poiesis* as a supplement to the overall portrayal of design in this hybrid approach. No method surveyed here succeeded completely in the element of *thought*, but if more methods were examined, it is possible that a method succeeding greatly at this could be found to be included in this hybrid model. This hybrid method example is shown in Table 5. Other hybrid methods are possible, especially if more methods were compared to *Poiesis*.

Table 5. EXAMPLE HYBRID METHOD BASED ON *POIESIS* AS AN EVALUATIVE FRAMEWORK.

Element of Poiesis	*Method to be used*
Plot (Purpose)	Cross – Objective tree and brief
Character (Quality)	Pahl and Beitz – Function structure and consideration of feasibility/goodness
Thought (Analysis)	Pahl and Beitz – modeling and calculations of embodiment stage; Cross – mathematical analysis; or another method that includes both principles
Diction (Communication)	Jordan – User-centric specifications and linking to six categories of product characteristics, metaphors
Melody (Aesthetics)	Jordan – Aesthetic principles: “Objet d’art”, “engagement and consistency”, color and form
Spectacle (Embellishment)	Jordan – experiential properties from formal properties, prototyping and modeling
Overall process portrayal	Cross – iterative, cyclical process, communication and delivery of pleasure and function; with added relative value of elements from *Poiesis*

Relationship between HCD and traditional methods

The results of the semantic analysis also provide a better understanding of the limitations and issues of traditional and HCD methods and how they relate to each other. The HCD methods have emerged more recently due to the inability of traditional methods to handle certain elements of a design, such as the artistic value, or style, and how emotional values are communicated to the user. These are the later stages, or elements, in *Poiesis*. The HCD methods have not, however, been readily adopted as superseding design methods because they do not incorporate the stages of the design process that deal with the artifact's technical and functional side—the earlier stages of *Poiesis*. Additionally, they do not readily indicate how they fit with traditional methods. This is a significant observation because some have claimed that HCD methods should have supremacy over traditional design approaches—that HCD is the starting point and not a later stage of refinement [33]. Although Aristotle suggests starting with an understanding of the user, delivery of emotional benefits is not addressed until later in *Poiesis*, once the design has been more established. This assertion of supremacy may have hindered the adoption of HCD because it doesn't account for the reality of how design must proceed. HCD methods generally start with this understanding of the user and then skip ahead to later stages of communication of emotions, without addressing how this point was reached. The two HCD methods examined are not more important or fundamental according to Aristotle, because they are weak in the *most important and fundamental* early stages of design. They are useful in addressing later more user-centric stages, which in a competitive design environment can give an important edge in products. However, focusing on the HCD methods at the neglect of methods that address earlier stages is detrimental according to *Poiesis*.

In order to receive the benefits of both approaches, designers should draw from both types of methods where appropriate. Determining how to combine traditional methods and HCD methods can be difficult and doing so haphazardly risks omission of important considerations in the design process. In the analysis of the previous section we have provided an example of how these two types of methods can be combined more meticulously using *Poiesis* as a foundational design framework.

Future work

The identification of these elements of *Poiesis* as relevant to engineering design should encourage further incorporation and coordination of research in other design disciplines (i.e. architecture) with engineering design. For instance, the analysis we have carried out here to identify principles of *Poiesis* in methods could also be carried out with design methods from other disciplines. This would indicate which elements have strong methods and techniques that can be brought over to engineering design to strengthen the practice.

Future work also should evaluate the effectiveness of various methods at realizing a particular principle from *Poiesis*. In this research, we took a binary approach to examining the presence of different principles. Moreover, we determined if a principle was either present or absent from a design method but did not attempt to measure or evaluate how well a method achieves a certain principle. Additionally, although *Poiesis* instructs about the relative importance of the elements, within each element the principles are viewed as equal. This makes it difficult to determine the criticality of leaving out a principle. Here, it has simply been assumed that each principle is equal in importance with the others in the same element. Research could be carried out evaluating the effectiveness of methods at different principles and the criticality of individual principles.

In this research we have taken an important first step toward understanding how *Poiesis* can be related to engineering design and how it can be useful as a basis for a comprehensive method that incorporates traditional and HCD methods. It would be informative to compare other engineering design methods to *Poiesis* in the same manner. This will lead to more and better options for hybrid methods. One of the most important steps that can be taken based on this research is to more clearly define a hybrid method such as the one proposed (Table 5) and validate its effectiveness.

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APPENDIX: DETAILS OF ANALYSIS

This appendix contains tables explaining the analysis and results of the comparison of principles to each design method. The sections and page numbers relevant to each principle are included.

Table A-1. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH PAHL & BEITZ.

Principles	Pahl & Beitz (1984)	Explanation	Section	Page numbers
Plot (Purpose)				
1		Not addressed		
2	x	Crux of task; abstraction of problem allows for influence and responsibility, such as for environmental concerns	5.2.1, 5.2.3	59, 65
3	x	Function structure; logically necessary	5.3.1, 5.3.3	66, 69
4	x	"ignore the particular or incidental"; analogies	5.2.1, 5.4.1-4	58, 85
Character (Quality)				
5	x	"Good ideas are always scrutinized…"; promising combinations should be pursued and the reasons they are preferred laid out	5.4.2, 5.5.1	86, 109
6	x	Should only pursue ideas that meet specifications	5.5.1	109
7	x	Pursue ideas that are realisable	5.6	112
8	x	Function structure relates character to purpose	5.5	108
9	x	Recognizes and embraces intuitive process but encourages structure for this	5.4.2	86-87
Thought (Analysis)				
10		Not addressed in evaluation of concept variants	5.8.3	135
11	x	Rough calculations, construction of models to aid analysis; Embodiment design moves from the abstract to the concrete-as represented in the Poiesis model	5.7, 6.1	117, 167
Diction (Communication)				
12		Not addressed		
13		Clarity of function is mentioned but this tradeoff is not fully addressed	6.3.2	179
14		Not addressed		
Melody (Aesthetics)				
15		Not addressed		
16		Not addressed		
17		Not addressed		
Spectacle (Embellishment)				
18		Not addressed		
19		Not addressed		
General process				
20	x	Elements found were in the same order as that of Poiesis		
21		No hierarchy for importance of elements/stages		
22		Somewhat iterative, but linear rather than spiral		
23		Not addressed		
24		Not addressed		

Table A-2. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH ULRICH & EPPINGER

Principles	Ulrich & Eppinger (1995)	Explanation	Section	Page numbers
Plot (Purpose)				
1	x	Identifying customer needs - latent & explicit	3	34-35
2		Not addressed		
3	x	Metrics for needs, reflecting/refining	4	59-60, 65-67
4	x	"What" not "how", reflect on meeting needs and suitability to market	4	54, 71-73
Character (Quality)				
5	x	Pruning based on merit	5	93
6	x	Set quantitative goals	5	91
7				
8	x	Evaluating concepts w/ respect to customer needs	6	106-107
9	x	Structured methodology for evaluating	6	111
Thought (Analysis)				
10		Not addressed		
11		Not addressed		
Diction (Communication)				
12	x	Subjectivity; all potential users	8	172
13	x	Quality of the user interfaces; product differentiation	8	172-174
14	x	Emotional appeal	8	172-173
Melody (Aesthetics)				
15		Not addressed		
16		Not addressed		
17		Not addressed		
Spectacle (Embellishment)				
18		Not addressed		
19		Not addressed		
General process				
20	x	Elements found were in the same order as that of Poiesis	1, 2	9, 15-20
21		No hierarchy for importance of elements/stages		
22		Somewhat iterative, but linear rather than spiral		
23		Not addressed		
24		Not addressed		

Table A-2. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH CROSS

Principles	Cross (2000)	Explanation	Section	Page numbers
Plot (Purpose)				
1	x	Clarifying design objectives/requirements	5	62-63
2	x	Brief, Black box	5, 6	62, 78-79
3	x	Objective tree	5	64-65
4	x	Black box, level of generality of specifications	6, 7	78-79, 93
Character (Quality)				
5		Not addressed		
6	x	Refer back to requirements	10	140-141
7	x	"Engineering characteristics must be real and measurable", Feasible combinations	8, 9	111, 125-126
8	x	Refer back to functions	9	124
9	x	Intuition coupled with rational open procedure	10	139
Thought (Analysis)				
10		Not addressed		
11	x	Calculate paramaters and compare utility	10	141-147
Diction (Communication)				
12	x	Identify customers' views of requirements and desired product attributes	8	108
13		Not addressed		
14	x	Draw a matrix of product attributes against engineering characteristics	8	110-111
Melody (Aesthetics)				
15		Not addressed		
16		Not addressed		
17		Not addressed		
Spectacle (Embellishment)				
18	x	Draw a matrix of product attributes against engineering characteristics	8	110-111
19	x	Identify relationships between engineering characteristics and product attributes	8	111-112
General process				
20	x	Elements found were in the same order as that of Poiesis	4	57-58
21		Not addressed		
22	x	Process is recognized as being iterative and cyclical	4	58
23	x	Role of producer, consumer, and designer	13	199
24	x	Quiz customers in depth about preferences	8	108-109

Table A-4. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH JORDAN

Principles	Jordan (2000)	Explanation	Section	Page numbers
Plot (Purpose)				
1	x	Holistic understanding is "precondition" for specifications	1, 3	8, 58, 62
2		Not addressed		
3		Not addressed		
4		Not addressed		
Character (Quality)				
5	x	Need to generate subjectively good ideas to meet specifications	3	120
6		Not addressed		
7		Not addressed		
8	x	Property specification derived from benefit specification	3	120
9	x	Provides structure for designer to evaluate designs based on judgements, choice of methods	4	136
Thought (Analysis)				
10		Not addressed		
11		Not addressed		
Diction (Communication)				
12	x	Use understanding of target group to generate specifications	3	82-86
13	x	Use of metaphors in form; Retro forms; metaphors in HCI	3	92, 96, 116
14	x	Systematically link emotional responses to six categories of product characteristics	3	89-119
Melody (Aesthetics)				
15	x	"Objet d'art"	2, 3	12, 82
16	x	"Engagement and consistency" leading to believability in HCI	3	116
17	x	Color and Form explained and broken down in detail	3	89-101
Spectacle (Embellishment)				
18	x	"Create particular experiential properties…through the manipulation of the formal properties"	3	89
19	x	Prototyping and modeling allows for evaluation of response, fitting into environment, and cheap alterations	3	128-129, 131
General process				
20	x	Basic description of process proceeds in the same order as that of Poiesis	3	58
21		No hierarchy for importance of elements/stages		
22		Not iterative or cyclical		
23	x	Formal properties to deliver desired experiential properties	3	86-87
24	x	Hierarchy of consumer needs-advancing from functionality to usability and pleasure	1	4-6

Table A-5. RESULTS OF A SEMANTIC COMPARISON OF POIESIS WITH BOATWRIGHT & CAGAN

Principles	Boatwright & Cagan (2010)	Explanation	Section	Page numbers
Plot (Purpose)				
1	x	Which emotions resonate with user, fit with brand	6	79
2		Not addressed		
3		Not addressed		
4		Not addressed		
Character (Quality)				
5		Not addressed		
6		Not addressed		
7		Not addressed		
8	x	"Features that realize the strategy"	6	80
9	x	eMap provides structure that can be adapted to designer's preference	6	85
Thought (Analysis)				
10		Not addressed		
11		Not addressed		
Diction (Communication)				
12	x	"This assessment should reflect the customers' perspective"	10	149
13	x	Shape grammars with variation to match preferences	7	119-120
14	x	Touchpoints	7	99
Melody (Aesthetics)				
15	x	Importance of aesthetics	7	120-121
16		Not addressed		
17	x	Aesthetics can be broken down into form features leading to identity of product	7	101-103
Spectacle (Embellishment)				
18	x	Deliberately evoke emotion	1	18, 21
19	x	Test, get feedback, iterate	7	117
General process				
20	x	Basic description of process proceeds in the same order as that of Poiesis	6	80
21		No hierarchy for importance of elements/stages		
22		Not cyclical		
23	x	Design of product should involve deliberate emotional connection to the customer	7	99
24	x	Function is required to prevent negative emotions but positive emotions must be addressed separately	1	12