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Rubric for Assessing Epistemological Understanding of Students Who are Learning Design.

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INTRODUCTION

There is an extensive base of literature that attempts to describe how college students understand "knowledge" and their role in generating it. Educators draw from this literature to help students develop increasingly sophisticated ways of using knowledge. Although existing research aims for broad generalizability, it is clear that various disciplines have developed their own unique value systems. Scholars of "hard," physical science are likely to hold very different ideas about the nature of "fact" and "inevitability" than those in the "softer," social sciences [1]. Various disciplines conceptualize, use, and generate new knowledge in ways that differ dramatically, yet little research has been done to probe epistemological differences.

To help address the existing deficit of knowledge, this paper investigates epistemologies that are specific to design-related disciplines. It presents a new tool—a rubric—that can be used to assess the cognitive, intellectual, and epistemological development of students who are learning to design. The rubric is appropriate for use with students of engineering, architecture, art, and a host of other fields that require creative thinking (e.g., product and software design).

Design students must learn to integrate rational, analytical, and intuitive thinking in the development of meaningful, creative, and elegant solutions, objects, products, structures, and places. Fostering such ability appears to be critical for the development of society as a whole [2]. Constructing knowledge in areas where levels of agreement are low and uncertainty is high—or where situations and contexts are emerging or transient—requires a process of continual re-negotiation [3]. At this point in time, technology is changing quickly, as are what Kunstler [4] calls "the categories of knowledge and interpretation." He insists "the nature of cognition and information processing itself" is shifting dramatically. The Boyer Commission's report on educating undergraduates recognizes transformation of this sort [5]. It identifies interdisciplinary programs and studio-based pedagogies as effective ways to prepare students for an uncertain future. Understanding and managing design students' development is key to promoting their healthy, positive growth [6, 7]. This paper unveils a new *Epistemological Development Rubric for Designers*, created to help educators assess students' epistemological understandings and also track changes in students over time (please see Table 1).

1 THE EPISTEMOLOGICAL DEVELOPMENT RUBRIC FOR DESIGNERS

The *Epistemological Development Rubric for Designers* is provided in Table 1. It adopts characteristics of the *Design Strategies Rubric* created by David Crismond, a professor of science education at the City College of New York [8]. Onto Crismond's framework, it superimposes operational definitions of epistemological development that have been created by William Perry [9], Marcia Baxter Magolda [10], Mary Belenky and her colleagues [11], and Patricia Love and Victoria Guthrie [12]. Each of these foundational components will be discussed following the new rubric.

Table 1. Epistemological Development Rubric for Designers

Revolutionary Restructuring
The Great Accommodation

Perry > **Baxter Magolda >** **Belenky *et al.* >** **Love & Guthrie >** **Crismond** **Phase of Design** V	**Dualistic Thinking** **Absolute & Transitional** **Received & Subjective** **Unequivocal**	**Multiplistic Thinking** **Independent** **Procedural** **Subjectivist**	**Relativistic & Committed Thinking** **Contextual** **Constructed** **Generative**
I. Exploring the Challenge	Little exploration. Makes brief reading, overlooks research, & makes decisions prematurely. Looks for answers in external authorities. Reflects awe in authority figures (received) OR reflects belief that his/her own knowledge is superior to others (subjective). Sees truth & knowledge as: external, not open to questioning, universal and context-free, constant, and the same everywhere.	Seeks to map a process for achieving results. Conducts some research. Sees instructor as providing context for exploration of knowledge. Emphasizes procedure with evidence of doubt (separate) OR evidence of belief, empathy, and care (connected). Expresses an increased sense of uncertainty, ambiguity, & complexity. Often adopts view that all views are equally valid and that opinions are sources of truth.	Plunges into exploration. Embraces *process* as a means for generating new ideas. Holds off on making decisions until challenge has been explored from many angles. Integrates existing info & research. Conducts quick studies/tests to explore a range of ideas. Reflects personal integration of info based on rational inquiry (includes setting goals, asking what is needed as well as how things work & why). Integrates personal experience & reflection (perhaps generating new paradigms, insights, and judgments). Shows evidence of listening to others without losing ability to 'hear' own voice.
II. Generating, Building, and Communicating Ideas	Tries to look for keys in professor's statements. Works in linear steps OR haphazardly works on whatever happens to emerge. Learns through imitation, by acquiring information & competence from professors. Reflects a utilitarian approach to knowledge. Works to receive and/or master knowledge (absolute) & gradually begins to accept that some knowledge is uncertain. Seeks to receive & reproduce knowledge but lacks confidence in ability to create new truths	Begins using rules-of-thumb to help make choices. Acknowledges multiple viewpoints & considers how to determine which is "best." Still sees knowledge as coming from external authority--from asking what others expect & how to do it. Views knowledge as mostly uncertain. Constructs an individual point of view but does not consistently seek to provide supporting evidence for it. Emphasizes procedure & impersonally applies a	Proposes personal goals (additional personally relevant requirements) for each new project. Reflects idea fluency & uses problem-solving strategies in any order, as needed. Uses words, drawings, & models to explore ideas & show how parts connect & inter-relate. Uses diagnostic vision, addressing problems & troubleshooting ideas. Still recognizes multiple views but seeks congruence & simplicity. Seeks new experiences (perhaps re-constructing past conceptions on basis of new experiences, developing new paradigms, or creating new dialectics). Sees legitimacy of knowledge claims as determined contextually. Constructs individual point of view with supporting evidence. Integrates objective & subjective thought

	(received) OR insists something is true without deeply questioning it (subjective).	procedure for establishing truth (separate) OR draws from personal experience (connected).	(i.e., thinking and feeling). Is an intimate part of what he/she knows. Is articulate, self-aware, caring, & concerned (uses both separate & connected thinking). Realizes power to generate, produce, author, or originate (knowledge, future, self, creations, truths, or realities).
III. Testing and Evaluating Solutions, Reflecting on Practice	Avoids rigorous testing. Shows very little awareness of his/her thought process. Values grade over learning. Pays too much attention to simple pros & cons. Has an unfocused way of testing & troubleshooting. Shows little self-reflection or monitoring of action. Seeks clear means to concrete ends. Tests only against stated requirements (received) OR assumes validity subjectively without rigorous testing (subjective).	Tests multiple options but does not rigorously question the established processes for testing. Reflects emerging awareness of own thought process. Begins to probe trade-offs & benefits. Values professors who promote independent thinking & facilitate exchange of opinions. Emphasizes procedure with evidence of critical thinking. Listens to reason with implicit adversarial or impersonal tone (separate) AND/OR displays trust & patience in process (connected). At this stage, the student may flip back & forth between separate and connected thinking.	Shows clear awareness & enjoyment of own thought process. Reflects a balanced system of weighing benefits & trade offs in making decisions. Approaches design as a managed, iterative process. Uses feedback to improve ideas. Practices reflective thinking, keeping tabs on design work in a meta-cognitive way. Seeks competence in work & social roles. Uses knowledge to achieve internalized standards of excellence & serve society. Asks key questions & poses key dilemmas. Fosters personal experience & personally generated insights. May confront and seek to reconcile paradoxes & conceptual conflicts. Sees role of professor as creating learning environment by: endorsing contextual application of knowledge, helping students evaluate various perspectives, providing opportunities for mutual critiques between students & instructors. Is inherently reflective. Struggles to find balance. Reflects "passionate" knowing. Practices meta-cognition by reflecting on & critiquing his/her design process and outcomes.

Table 1 provides a synthesis of existing theories. It represents a tool for evaluating behaviors exhibited by design students. Each box in Table 1 attempts to describe student behaviours typical at a various phases in the design process. Phases are listed in the left-hand column. Behaviours of beginning designers (i.e., students with novice ways of understanding and using knowledge) are identified in the second column. The third column describes students who are moving toward more complex ways of thinking. The final (right-hand) column describes experienced designers who are able to address complex, ill-defined problems effectively. Prior theorists' descriptions are color-coded in this rubric, with black text providing summation of other definitions in the box.

To use this rubric, one simply reviews poignant in-class behaviours, interview responses, or written statements and circles statements on the rubric applicable to each one. After analysing a number of statements, a pattern should begin to appear indicating where the student's overall level of development falls. The rubric is particularly helpful in cases when the student is asked to reflect on the design process and write about it periodically over time and thus provide rich data for qualitative analysis. This is because the more data points a researcher has, and the longer period of time over which these data points have been collected, the more accurate the assessment of change over time will be.

Using this technique, an instructor can quickly assess where the student's comments fall at various stages of the design process. The goal of the instructor should be to help move each student from left to right as he/she simultaneously learns to master the design process. The overall pattern will also indicate if the student is approaching "Revolutionary Restructuring" or has successfully made "The Great Accommodation" as represented by the bold line on each of the tables above.

Table 2. Comparison of Theories, derived from Love & Guthrie

The Great Accommodation

Love & Guthrie (1999)

Unequivocal Knowing	**Radical Subjectivism**	**Generative Knowing**

Perry (1970)

Dualism		**Multiplicity**		**Relativism**	**Commitment to Relativism**			
1	2	3	4a	5	6	7	8	9
			4b					

Belenky, *et al.* (1986)

(Silence)	**Received**	**Subjective**	**Procedural**	**Constructed**
			Separate	
			Connected	

Baxter Magolda (1995)

Absolute	**Transmitted**	**Independent**	**Contextual**
Mastery	Impersonal	Individual	
Receiving	Inter-personal	Inter-individual	

King & Kitchener (1994)

Pre-Reflective			**Quasi-Reflective**	**Reflective**		
1	2	3	4	5	6	7

2 THEORIES SUPPORTING THE NEW RUBRIC

In the 1960s, student development theory emerged from the then-young field of cognitive psychology. Student development theorists adopted cognitive psychology's established way of looking at the world. Table 2 illustrates relationships between the stages of epistemological development identified by a number of scholars who adopted this lens.

The fundamental research question of cognitive psychology has been defined as: *What can we learn about an individual by examining how he/she acquires, stores, and processes information* [13]*?* Cognitive psychology, therefore, offers an ideal frame for analyzing and evaluating the cognitive development of design students.

Whereas Table 2 illustrates relationships between various cognitive development theories that are not design specific, Crismond's rubric (Table 3) uses operational terms to describe design-related activities that distinguish low- and high-level design abilities. The right-hand column describes activities that professors associate with skillful design thinking.

Similar to the bold, vertical line Love and Guthrie used to depict a significant threshold, the vertical line in Crismond's rubric emphasizes the difference between beginning designers' (novice) activity and informed designers' (more expert) action. Crismond has not named the transition separating the two realms, but it seems reasonable that this transition could occur in the manner described by Love and Guthrie as *The Great Accommodation* and by Perry as

Revolutionary Restructuring. This moment, according to Love and Guthrie, is the point at which the individual realizes that uncertainty is everywhere. As the place of knowledge, truth, and authority disintegrates, the individual's own role as knower and authority emerges.

Table 4, which draws from Arthur Chickering's work [15], is helpful in understanding how an individual's conception of knowledge typically changes over time. It shows how these changes relate to William Perry's categories as well.

In the past, education and design experts have studied patterns among large groups of architecture students. These experts have touted the benefits of hands-on, studio-based, architectural education. However, they have also identified the need for architecture professors to more carefully facilitate healthy development of architecture students—in order to avoid detrimental effects that sometimes occur when students exceed their limits [10, 12, 14]. The proposed rubric represents a step toward addressing that need. Moreover, it aims to help educators become more aware of when and how students are developing epistemologically and when their misconceptions might be hindering design achievement.

Although prior studies have utilized a collective (sociological) perspective, they imply the need to conduct localized (psychological) studies of key developmental issues. This study borrows heavily from the sociological traditions that informed prior work in architecture, but utilizes the cognitive psychology framework that is popular with scholars from the field of student development.

Table 3. Design Strategies Rubric by David Crismond

Phase of Designing	What Beginning Designers Do	What Informed Designers Do
I. Explore the Challenge	**Premature Decisions** – make choices too soon, after reading brief.	**Delay Decisions** – hold off from making decisions until exploring the challenging.
	Skip Research – and instead start posing solutions immediately.	**Do research** and **information searches** about the problem.
	Do **few** or no early **investigations** or conduct **confounded experiments**.	Do **valid tests** to help designers learn quickly about the design.
II. Generate, Build & Communicate Ideas	**Idea Fixation** – get stuck on their first design ideas that they won't let go of.	Practice **Idea Fluency** – via sketching, brainstorming & rapid prototyping.
	Describe & sketch devices that would not work if built.	Use **words, drawings & models** to explore design ideas and show how parts connect and work together.
	Have a generalized, **unfocused way** to view tests and troubleshoot ideas.	Use **diagnostic vision** to focus attention on problems & troubleshoot ideas/devices.
III. Test & Evaluate Solutions, Reflect on Practice	**Ignore** or pay too much attention to pros or cons of ideas without also thinking of **benefits & trade offs**.	**Balance** systems of **benefits & trade offs** when **making** design **decisions**, & use rules of thumb to make choices.
	Design in **haphazard** ways, working on whatever problems emerge. Do design as a set of steps done once in **linear order**.	Do design as a **managed, iterative process**, using feedback to improve ideas. Strategies used in any order, as needed.
	Do **tacit** designing with little self-reflection & monitoring of actions.	Practice **reflective thinking** by keeping tabs on design work in a meta-cognitive way.

3 TESTING THE NEW RUBRIC

The *Epistemological Development Rubric* is currently being tested for validity using blogs written across the span of a semester by 55 college juniors and seniors majoring in art and design, architecture, and materials science engineering [16]. The students were enrolled in a three-credit elective course where they worked in multi-disciplinary teams and documented their experiences on the Web [17]. The students had to navigate through a series of ill-defined

problems and come to terms with shared authorship. The students worked in teams of six, making it possible to compare and contrast individuals' interpretations of similar events. It is also possible to assess differences by major and by students' level of experience with design.

Current testing involves (a) analyzing the content of blogs created by students engaged in the practice of design in order to (b) assess the students' modes of thinking at various points in time and to (c) evaluate how each student's thought processes changed over time.

It is important to recognize that a student's work may show some signs of *relativistic* thinking while the student is at a position left of The Great Accommodation/Revolutionary Restructuring line. The current study endeavors to determine when the student's work reflects true passage across this line, meaning that the student has thoroughly incorporated the major tenets of *relativism* and relies on this way of thinking to make most decisions.

Table 4. Typical Progression Among Undergraduate College Students

Perry Position	Dualism	Multiplicity	Relativism	Commitment
Individual's **motivation for** obtaining education is	to meet an immediate need.	to gain social and professional recognition.	to become more useful to society & more competent with regard to competitive standards.	to enhance understanding of self/world/life & capacity to influence one's own destiny.
Individual's **conceptualization of** "knowledge" is	a commodity that can help one achieve goals (by essentially implementing a series of ritualistic actions).	general information necessary for fulfilling certain roles in society, or a set of objective truths determined by authorities.	know-how, personal problem-solving skills, & the ability to resolve conflicting views through rational processes.	personally-developed insights regarding self/world/life that is generated through a dialectical process (subjective insight & paradox are celebrated).
Individual perceives knowledge as **useful for**	obtaining things & achieving concrete goals.	achieving social importantance & meeting other peoples' expectations.	contributing to society & meeting internal standards of excellence.	becoming whole & transforming his/herself and the world.
Individual perceives that knowledge **comes from**	external authorities – and involves asking authorities how to get things.	external authorities – and involves asking them what they expect and how to achieve it.	a process of rational inquiry that integrates various viewpoints and sources (that includes identifying needs, setting goals, understanding how things work & why).	experience and reflection (including self-generated insights, judgments, & paradigms).
Individual's primary **process for** learning involves	imitation of authorities and memorization of truths and techniques identified by them.	recognizing inconsistent definitions & conflicting viewpoints and beginning to reconcile evaluate them.	seeking congruence & simplicity by reconciling inconsistencies & conflicting ideas through logical analysis.	seeking out new experiences & revamping previously held ideas in light of new experiences (at times developing new paradigms).
Individual **expects the teacher or institution to**	explain how things should be done all the while gaining and maintaining students' interest.	provide training, deliver content, & certify student's level of knowledge & skills.	offer programs that: enhance knowledge & skills; require rational analysis & practice; and can be assessed & certified.	confront significant paradoxes, pose key questions/dilemmas, enhance personal experience, & help students generate their own insights.

3.1 Research Question

The research question for this test asks: *To what degree do the blogs created by traditional-aged college students engaged in the process of design reflect "The Great Accommodation" and transition to "generative knowing" as defined by Love and Guthrie and "Revolutionary Restructuring" as defined by Perry?*

3.2 Research Methods

The study is using the design process outlined by Koschmann, Myers, Feltovich, and Barrows [18] to test the validity of Table 1. These scholars have identified the following steps to design: (1) problem formulation; (2) development of a solution through a self-directed learning approach; (3) re-examination of the problem to test the proposed solution; (4) abstraction where the solution is contextualized with other known cases; (5) a final stage where individuals reflect upon and critique their learning process, seeking to identify areas for future improvement. The steps described by Koschmann *et al*. reflects the tenets of relativism/contextualism/constructivism/generative knowing as described in Table 1. If design students are successfully achieving the abilities these scholars describe, then they should also reflect transition across the line of The Great Accommodation/ Revolutionary Restructuring.

4 CONCLUSIONS

A study of students' statements and reflections promises to shed light onto the way emerging designers make decisions and how their approach to knowledge changes as they develop expertise in design. Further study—such as the test described briefly in this paper—holds the promise to (a) improve design education, (b) enhance student development theory, and (c) improve studio pedagogy as it is incorporated into more disciplines [5, 14].

Such analysis—to assess how and when various design students make The Great Accommodation and achieve Revolutionary Restructuring—promises to contribute valuable new insight to the literature on student development theory. Through such work, researchers and instructors may ascertain if design students typically adopt *relativism* during their undergraduate years and to what degree they embrace its tenets. This process can help researchers and instructors understand when and how students achieve high-level development and how consistently the students can apply *relativistic* or *generative* thinking. By become more aware of how development is occurring in general and in specific classrooms, instructors can tweak their own behavior and improve studio teaching/pedagogy.

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