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INFORMATION SYSTEMS EDUCATION JOURNAL

Editors

Beyond Competency: The Imperative to Foster Professionalism in Computing Graduates

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Abstract

The Computing Curriculum 2020 project report, CC2020, Paradigms of Global Computing Education prescribes a competency model for describing curricula that challenges baccalaureate curriculum design to integrate "knowing why" into a fifty-year tradition of guidelines focused on "knowing what." Prescribing this competency model is a call to action to understand the scope of society's aspirations dependent upon computing and, in turn, computing education. These aspirations remind us that the character of a computing professional is as important as her computing expertise. Computing professionalism demands a well-formed mindset, of which computing competency is an essential ingredient. We argue, however, that the whole recipe for professionalism in computing must recognize and reflect on its transformative impact on the systems of society, both technological and human. We extrapolate CC2020's competency model into a framework through which academia and industry can partner to advance computing as a profession by integrating the technological, sociological, and ethical dimensions of computing. Finally, we present a rationale of professionalism in computing where competent practice is informed by the critical aspects of accountability: risk, responsibility, and consequence, where developing a professional mindset of inclinations and dispositions of character is not ancillary, but essential to educating baccalaureate computing graduates.

Keywords: professionalism, competency, mindset, dispositions, accountability, computing education, curriculum design.

1. INTRODUCTION

Computing has become integral to virtually every aspect of contemporary life – as a tool for mediating and managing human interactions (Lyytinen and Yoo, 2002). Computing systems and applications can wield tremendous benefit and tremendous risk depending on the carefulness and vigilance of analysts, designers, developers, and managers of computing applications. The benefits seem obvious, but there has been harm.

To prevent practitioners from developing software-driven systems that inflict harm, the Software Engineering Code of Ethics and Professional Practice includes eight principles and advice on applying them. The first and most important of these principles is that software engineers "shall act consistently with the public interest" (Gotterbarn & Miller, 2009, p. 67). When these principles are ignored or violated, the results can be disastrous. For example, 17 patients died because of overexposure to radiation in software-generated treatment plans that were inconsistently checked for adherence to standards for patient safety (Borras et al., 2004). In 1994, Aeroflot Flight 593 crashed and killed all 75 people on board because the pilot's son unknowingly disengaged the A310's autopilot control of the aircraft's ailerons. A few minutes later, the aircraft crashed into the Kuznetsk Alatau Mountain range (Aeroflot Flight 593, 2017). Similar examples abound on the Internet!

If baccalaureate computing education is to prepare students to be respected and trusted purveyors of the tools and services of computing, then our curricula must take account of *how* and *why* respect and trust are safeguarded. Simply summarized, computing graduates are expected to ply their trade in society as professionals. And although "professionalism" is a familiar festoon imprinted upon most published computing curricula, we believe that more explicit description and documented pedagogy are needed if this claim can be honored as a meaningful characteristic of a curriculum design.

Institutionalized professions in which certification and licensure are the norm have codified the definition (and assessment) of competencies in practice, in the context of tasks demanded of the profession. These traditions date back decades, even centuries, in professions like nursing (Johns, 1995; Miller & Malcom, 1990), medicine (Wear & Castellani, 2000), and law (Cramton, 1982). Furthermore, these competencies are defined mainly based on the knowledge, skills, and dispositions (or attitudes) practitioners must learn and master to excel in their careers of service to society.

This paper examines the CC2020 competency model, its potential in baccalaureate computing education to frame professionalism in the formation of graduates as professionals. Competency has the potential to transform computing education (Leidig & Salmela et al., 2020; Waguespack & Babb, 2019). Computing competency is an essential ingredient in computing professionalism. The prospect of shaping a mindset enfolding professionalism in a computing baccalaureate is compelling. And although a baccalaureate may only be able to inaugurate a graduate's trajectory toward professionalism, that is undoubtedly a critical trajectory worth pursuing. After examining competency-based curricula for computing, our paper concludes with a discussion of the computing profession as an institution.

2. CC2020: THE PRESCRIPTION FOR COMPETENCY

The mission of the CC2020 project […] is to produce a globally accepted framework for specifying and comparing computing baccalaureate degree programs that meet the growing demands of a changing technological world and is useful for students, industry, and academia. (Clear & Parrish et al., 2020)

The CC2020 report followed upon its antecedent, the CC2005 report, and therefore attempts to lay groundwork for a continuous expansion of academia's commitment to educating the computing professionals of the 21st century. CC2020 was neither engaged in evaluating nor modifying the content of any subdiscipline, but rather attended to how computing curricula might be advanced by means of analysis with the prospect of visualization for comparing curricula. Adopting a competency model for describing computing curriculum enables their authors and curators to coordinate using a normalized, encompassing epistemological framework.

The CC2020 competency model enables dramatically amplifying curriculum representation both in form and scope. Where the traditional form and primary focus of computing curriculum guidelines has been on the knowledge computing students need in terms of "knowing what," the competency model enfolds a depth of understanding in applying that knowledge, "knowing how." And perhaps the more radical enhancement is attending to "knowing why" one might want to apply what they know in a certain context and what result might be intended and assessed.

The simplicity of the competency model belies the sophistication and depth of reflection entailed. Competency obliges designer reflection: *what*, *how*, and *why* a practitioner should approach fulfilling a particular *task*. (See Figure 1.)

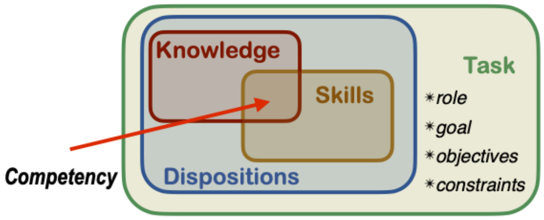

Figure 1: Competency = [Knowledge + Skills + Dispositions] in Task (Clear & Parrish et al., 2020)

The *Knowledge* component proceeds largely from the tradition of KA-KU (knowledge area, knowledge unit) ("knowing what") that predominated computing curricula guidelines until the recent IT2017 and IS2020. The *Skills* component derives from the Bloom's levels of cognitive process; effectively, how sophisticated is the practitioner's capacity of applying that knowledge ("knowing how"). Thus, knowledge always emerges as paired with a level of skill. (See Appendix C.) *Dispositions* refers to the temperament or quality of character ("knowing why") that inclines the practitioner to engage their choice of knowledge + skills. (See Appendix D.) The performative dimension of a specification of competency is situated by a statement of *task*, which defines a circumstance of risk, responsibility, and consequence. Performing a task entails intention or purpose that may be adjudged to a degree of professionalism. Essentially, a competency specification expresses a model of knowledge skillfully and purposefully applied in the successful accomplishment of a task.

3. CC2020: COMPUTING KNOWLEDGE

The CC2005 project performed an exercise constructing a taxonomy of computing based upon topics published in curriculum guidelines of the contemporary computing subdisciplines. CC2005's taxonomy was negotiated based on the member expertise of the steering committee. Although not empirically derived through analysis of actual guideline details, the taxonomy was very instructive. Among computing curriculum stakeholders familiar with it, the CC2005 taxonomy and comparison of topic emphasis continues to enjoy broad respect.
CC2020 reprised CC2005's taxonomy exercise with several cycles of proposition, negotiation, and refinement to update the topical cross section of scientific and technological computing knowledge. CC2020 arrived at 34 topic areas. (See Appendix A.) To further organize the topics the list is ordered based upon the semiotic ladder (see Table 1). The ordering ranges from concepts inherently objective or empirical (physical, empirical, syntactical) to those inherently subjective or critical (semantics, pragmatics, social world). Semiotic ordering clusters computing topics that generally associate as degrees of technically rational (physics, mathematics, logic, etc.) at one extreme and topics more generally regarded as degrees of subjectivity (management, sociology, psychology, politics, etc.) in the opposite direction.

Semiotic Ladder	Semiotic Layer Description
Social World	Beliefs, expectations, functions, commitments, contracts, law, culture
Pragmatics	Intensions, communications, conversations, negotiations
Semantics	Meanings, propositions, validity, truth, signification, denotations
Syntactics	Formal structure, language, logic, data, records, deduction, software, files
Empirics	Pattern, variety, noise, entropy, channel capacity, redundancy, efficiency, codes
Physical	Signals, traces, physical distinctions, hardware, component density, speed, economics

Table 1: The Semiotic Ladder (Stamper, 1991; Liu, 2000)

Once arranged semiotically, each steering committee member provided their estimate of the range of emphasis that each topic might be expected to represent for each of the six currently published computing subdisciplines (0-none, 5-most). The assembled estimates are shown in Appendix A. This appendix presents the average between the group's max and min emphasis yielding the bar graph in Appendix B for each topic juxtaposing the six subdisciplines. Thus, each subdiscipline's distinguishing balance of emphasis among the computing topic areas reveals its "fingerprint."

Computing subdiscipline description has long been preoccupied by a characterization of practitioners as "knowing what." CC2020 reviewed computing guidelines describing Information Technology, Information Systems, Cyber Security, Software Engineering, Computer Science, and Computer Engineering with others in development. (See Figure 2.)

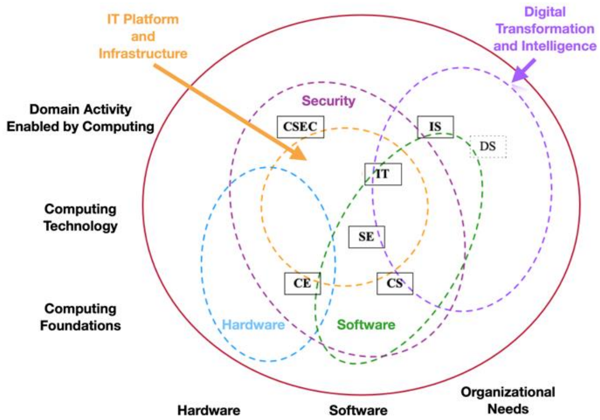

Figure 2: CC2020 Landscape of Computing

Adopting the competency model-based approach to curriculum description may elect the task domain as a more faithful, descriptive choice for identifying a computing subdiscipline (i.e., CS, SE, CE, etc.). But it is noteworthy that subdisciplines constantly evolve hyphenating with other domains although labels are resistant to change even if they are to some degree misnomers.

Competency-based curriculum description offers a perspective on disciplinary identity crystalized in two aspects: the combination of knowledge-skill pairs needed to act competently and the task(s) that demonstrate that combination applied. Dispositions introduces a mindfulness (*intension)* as a qualifier for "task well done."

4. FROM PROFESSIONALISM TO COMPETENCY

A computing practitioner "knowing what" and "knowing how" can perform an almost limitless range of tasks using computing. But the character of the consequence of that action determines the degree to which that behavior is adjudged professional.

Professionalism is often somewhat circularly defined: (Merriam-Webster.com, retrieved Sept 1, 2021)

Professionalism: the conduct, aims, or qualities that characterize or mark a profession or a professional person.

Professional: a member of a profession or earns a living from a specified professional activity. In addition, most professionals are subject to strict codes of conduct, enshrining rigorous ethical and moral obligations.

Profession: a calling requiring specialized knowledge and often long and intensive academic preparation.

Professional behavior is marked by a mindful reflection upon risk, responsibility, and consequence in the discharge of task. These elements are intrinsic to professional conduct. The scope and quality of reflection distinguishes the professional from the amateur. A competency specification frames computing knowledge applied skillfully in a practical context of task informed by dispositions reflecting an attitude inclined toward a task well done.

Competency provides a versatile template for describing units of purposeful behavior, work. A system of competency-based specification can be used to define a course, program, curriculum, discipline, licensure requirements, or a job description. But the goals and objectives of CC2005 and CC2020 were never intended to stipulate or propose the extents or granularity of computing professionalism. Indeed, the CC2020 report discusses only in broad strokes a respect for humanity at large and individuals thereof. CC2020's competency model nevertheless provides a frame with which to describe the performative aspect of professionalism. The following describes the relationship between that performative dimension and a mindset of professional behavior.

5. DIMENSIONS OF PROFESSIONALISM

"Knowing what" and "knowing how" (knowledge + skills) bracket the operative potential of competency while dispositions inform the intensional, the motivation to act. Task specification sets a context within which behavior unfolds inspired by dispositions, mindful inclinations, to achieve a principled result, a task well done.

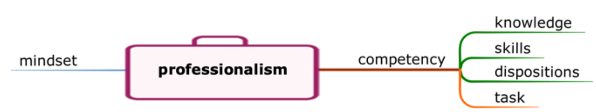

Figure 3: Competency inspired by mindset.

Competency Dimension – A competency-based curriculum defines a collection of tasks that define a domain of competency. Each task is elaborated by specifying the requisite knowledge and skill level to accomplish the task. Dispositions mediate the knowledge + skill application cuing reflection on risk, responsibility, and consequence. (See Figure 4.)

Dispositions can be defined as patterns of behaviors that are exhibited frequently and intentionally in the absence of coercion, representing a habit of mind. However, identifying desirable dispositions in engineering and computing education, or more particularly developing curricula with a goal to develop, reinforce or assess such dispositions is not common in engineering or computing. (Frezza et al., 2018; Frezza, Daniels & Wilkin, 2019; Frezza, Clear & Clear, 2020)

The CC2020 report proposes a set of eleven dispositions sourced from the literature of philosophy and theology (Newman, 2008; Frezza, Clear & Clear, 2020). A task defines the context of a competency, establishing the relevance of its knowledge and skills. Task descriptions provide an explicit context for describing, instructing, demonstrating, and guiding competency in action. Dispositions denote a desirable inclination for choosing and applying a competency to the effect of "good intentions." Where are the judgement points defined to be assessed in actions to be judged as "good?"

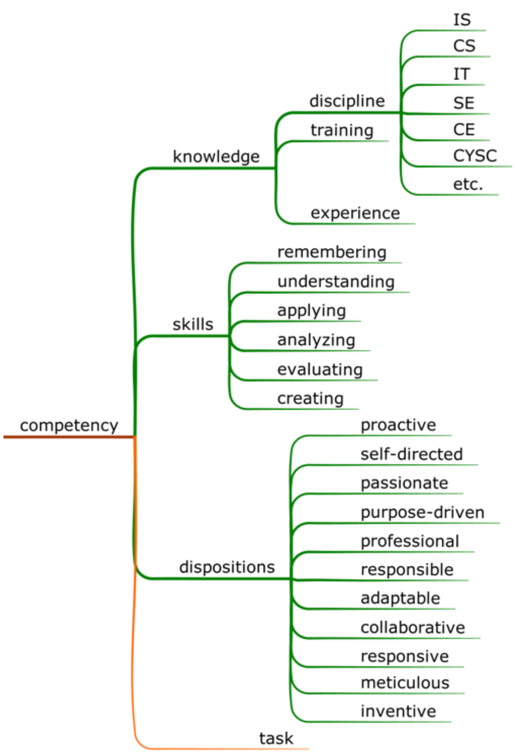

Figure 4: Competency Dimension

This question leads to Figure 5 that sketches a skeletal delineation of task elements. The flesh on that skeleton only emerges in the act of competency execution, accomplishing the task. Only in that execution can the practitioner realize the significance, priority, or urgency of the dispositions appointed to the competency. In effect, the practitioner channels "the mind" of the competency designer as she interprets design intention in the moment of the task. Congruence in that interpretation depends on the practitioner and designer sharing a mindset.

Mindset Dimension – In cognitive psychology a mindset represents the cognitive processes activated in response to a given task (French & Chang, 2016). In decision theory and general systems theory, a mindset is a set of assumptions, methods, or notions held by one or more people or groups of people. (Cambridge English Dictionary, retrieved Sept 1, 2021)

In the adapted quotations that follow, the design theorist refers to *mindset* as "appreciative system" and *practitioner* as "stakeholder" (Waguespack, 2019, p. 27).

A [practitioner]'s [mindset] cues what facts to attend to in any particular experience while that same experience results in a learning effect that informs, reinforces and refines the [practitioner]'s apprehension of value and significance, thus altering that [mindset].

[A… mindset] is a complex and emergent agency of choice in [practitioner] behavior situated in a social context.

[Practitioners] possess [mindsets] individually as their experience and judgements are personal. In a community of [practitioners] there are recurrent threads of experience, shared knowledge, and commonly held norms that proceed from culture: social, professional, religious, or intellectual. A culture commonly promulgates a standard of appreciation that facilitates a shared cooperation and collaborative decision-making that reinforces community – intentionally or unintentionally. Formal education, professional training, and certification, as well as, religious communities, all purposefully foster aspects of shared culture to shape community identity, goals, and expectations of behavior. Shared culture is a basic defining aspect of any community – formal or informal. Any human conception of satisfaction is founded upon [a mindset] that is subject in part to the subjective interpretation of norms and aspirations – individual and cultural metaphors.

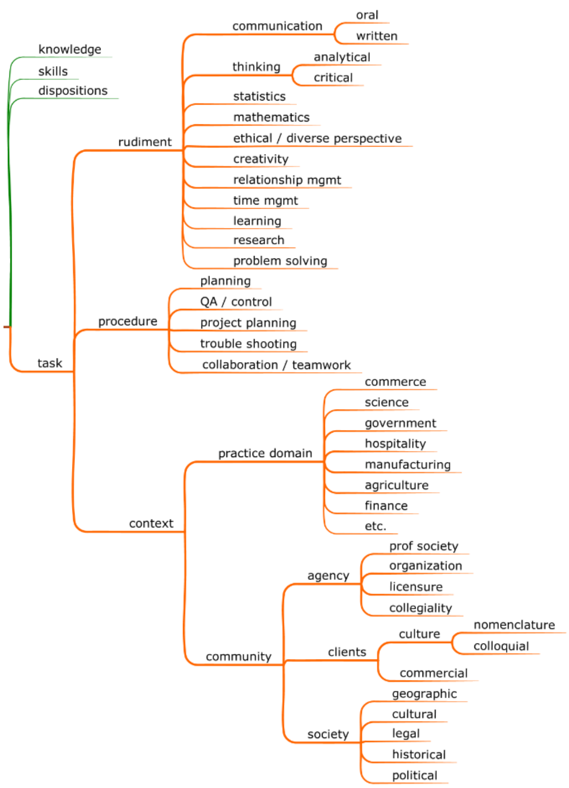

Figure 5: Competency: Task Aspect

Figure 5 lays out a portfolio of likely considerations, task characteristics that inform risk, responsibility, and consequence. The task graph denotes a figurative decision tree. The relevant variables amplified by enveloping dispositions to influence or prompt action. The significance of each variable would result from the immediate circumstance of the task at hand. While the literal processing of such a decision tree is conceptually possible, it is more likely that the assessment process will be navigated through the practitioner's tacit evaluation of the task informed by a mindset emerging from the practitioner's ongoing formal learning and practical experience.

It would be naive to presume that all combinations of disposition in an actual task context would be immune to tradeoffs. It would be further naive to assume that all "habits at hand" are beneficial or at least benign in every application of competency. It is the well-formed mindset that mediates the interpretation of disposition in the act of competent performance. That mindset must have a grounding in the values that are deemed appropriate for the professional engagement of competency.

Mindset Composition – Figure 6 characterizes elements of mindset that influence a perception of community "good." In the same spirit that CC2020 offered a prospective set of dispositions (see Appendix D), Figure 6 offers a nascent proposition for shaping the composition of mindset, a seed for discussion among designers to consider as they affirm a characterization of professionalism for their circumstance. One would expect such an explicit affirmation to be a necessary element of every curriculum description. This is a norm among professional societies who publish and renew their codes of conduct. Although we expect that well-formed mindsets of professionalism would have similarities among disciplines and subdisciplines within many cultures, we would also expect that particularities would merit variations.

Figure 6: Mindset Dimension of Professionalism

Figure 6 emerges from the authors' reflections upon their combined computing experience in professional and professorial practice.

Mindset inspires and justifies disposition. The introduction of dispositions by CC2020 represents a real potential for advancing the quality and effectiveness of computing curriculum description. It also presents a challenge and opportunity for our subdiscipline of information systems to renew the discussion of institutionalization in the IS profession.

6. DISCUSSION AND IMPLICATIONS

As a generative metaphor, we can conceive of the competency model as an affordance of detail and composition akin to adopting nutrition labeling that accompanies canned, prepared, and packaged food. This labeling creates truth in transparency so that the consumer can protect themselves and engage in self-regulation, should they elect to, rather than the food being of mysterious and uncertain origin and effect. The competency model provides a structure to articulate a similar level of transparency that suggests expected normative behavior upon which regulation and even cognitive disposition can be shaped and adjusted. There is an imperative that computing leave its adolescence behind and engage in maturity, as an obligation to society to operate at a level of accountability commensurate with other professions. As with most imperatives, the imperative must be comprehended, felt, and executed upon by the individuals we will recognize as professionals in computing.

Professionalization as Imperative - While we ascribe a key to professionalizing within the context of the competency model as possession of mindset, it would require scholarship beyond the scope of this article to define and defend mindset in full. That said, the literature on professional practice and organizations is replete with references to this capacity. An intriguing take on this would be mindset as an acuity required for improvisation; a competency that is applicable nearly uniformly across computing disciplines. Weick (1998) and Schön (1983, 1987) offer a rich illustration of improvisation in music, e.g., jazz. These treatises are useful not only in reinforcing the necessity of mindset and the practices that reinforce mindset, but they also reveal how difficult it is to put into words the strength and promise of mindset.

The challenge is to deconstruct and comprehend how other clearly recognized professions came to be as such. We argue that some candidate components of the institutionalization that mature professions exhibit are the extrinsic and intrinsic conditions that sustain these professions as institutions. For clarity, we hold nursing, medicine, law, and engineering (Kolb & Wolfe, 1981) to be good exemplars, in part because they are universally comprehensible across cultures and societies. Few words are required to explain these professions beyond affordances for local variation. Even then, there is a practical and conceptual adherence to the institution of the profession such that regional variances do not dilute the core expected competencies.

Professionalism Institutionalized - The process of institutionalization can be articulated in cultural/cognitive, normative, and regulative dimensions (Birdwell-Mitchell, 2018). As the "legs of a stool," these are mutually reinforcing dimensions that sustain the institution even in the face of change. This is not to say that the institutions themselves are static, but they are often self-correcting to core values and principles even as they adapt to emerging circumstances. The practice of law, medicine, and engineering have undoubtedly changed in fundamental ways with respect to practice. Still, their core function remains true: for medicine, it is to heal without harm; for law, it is the fair application of justice; and for engineering, it is to develop artifacts that coexist reliably and safely in nature. The regulative dimension enshrines and defines the limits, consequences, and imperatives of professional practice for clarity. The normative dimension expects a concomitant degree of self-regulation for the organizations and societies that arise to foster and shepherd the discipline, for both neophytes and veterans. The cultural/cognitive dimension provides the processes of indoctrination that socially "glues" the other components such that one internalizes – develops a mindset – that assures, within a reasonable margin, that individuals will reliably adhere to the maxims of the profession and discipline.

As human processes, the dimensions of institutionalization are evolutionary and, at human scale, slow compared to advances in technology. While technology is undoubtedly a facilitating catalyst, aspects of the "three-legged" model of institutionalization rely on the slower processes of internalization, normalization, and acculturation. Respected and readily identifiable professions institutionalized incrementally over time, mostly in evolutionary response rather than by fiat.

Towards Accountability in Professional Practice - Alone, the social processes of institutionalization must resonate at the point of action – the point where an individual practitioner internalizes the profession within mindset. The imperatives that result in accountability exist broadly within paradigms of motivation (Maslow, 1981). We postulate the following elements for a professional mindset: assessment of risk, acceptance of responsibility, and accounting for consequence. While not exhaustive, each of these components suffuses the execution of competency and, in that execution, renews the tacit models that ensure future demonstration of competency such that execution remains within the tolerances of professional behavior. We propose that through reliable and accountable behavior, these imperatives foster the credibility and reputation that fully institutionalized professions exude. If the imperatives are not "felt" at an individual level, such that they produce dependable responses in the execution of competency, then any aspects attributable to professional behavior lose their potency.

Mindset suggests that imperatives for professional conduct are explicit and implicit in a continuum. An ability to respond to the imperatives, aided by appropriate dispositions, can only be fully accomplished intrinsically. A suitable definition for this accountability is *being responsible for what you do and able to give a satisfactory reason for it, or the degree to which this happens* (Cambridge Dictionary, retrieved Sept 1, 2021). With this definition, there is no “other,” only the individual called upon to competently execute. Regardless of external influences, the internal regulation of mindset makes professional competency a personal matter. However, individual execution does not imply a set of subjective responses; a professional practitioner acts in obligation to the norms, regulations, and culture that bounds professional practice.

The importance of institutionalized professions is the degree to which the public can depend on expected behaviors. In this regard, an institutionalized profession retains its viability according to the reputation it garners and protects. Thus, errant behavior must be censured and corrected in a manner that is knowable and known broadly. A suitable definition for reputation is *the opinion that people in general have about someone or something, or how much respect or admiration someone or something receives, based on past behavior or character* (Cambridge Dictionary, retrieved Sept 1, 2021).

A competency model for computing curriculum design can and should hold the process of institutionalization as a strategic outcome. Such an outcome demands that a profession’s competent conduct be of high repute, with internal and external processes for regulation, normalization, and mindset. It is through these processes that institutions become worthy of respect, renewed in trust.

Authority and Public Trust - The last puzzle piece in institutionalization is authority. The need for authority is not apparent, as one would expect that regulation would attend to this need. However, regulation assumes some level of sovereignty. Respected and reputable professions assume sufficient internal accountability such that, in cases where sovereignty is clear, guidance on regulation is evident in partnership between legislative and practical elements. This partnership serves both to protect a profession’s reputation - to engender trust, and to protect public well-being - to utilize trust.

We find that this notion, public well-being, is the most illustrative to comprehend the professional practice of competent application of computing knowledge and skills. While dispositions are as broad as individuals, imperatives to adopt a mindset suggest that indoctrination, in service to the public good, becomes a reasonable imposition. Should the successful and profitable application of computing skills remain the sole validator of the computing disciplines, then the process towards institutionalization will remain stunted; technology changes and the possibilities created lead to an ends-means equation of short-term thinking. Further, it is not clear to what degree markets recognize broader and long-term risk such that appropriate responsibility can be identified, and consequence can be accounted.

	Cultural/ Cognitive	Normative	Regulative
Risk			
Responsibility			
Consequence			

Table 2: Accountability and Institutionalization Matrix

The dimensions in Table 2 propose a rubric to explore the relationships among components of institutionalization and accountability to understand the imperatives for mindset. Connecting these components can lead to competent execution, such that dispositions are applied appropriately in a professional mindset. In sum, navigating Table 2 affords expositive exercises that explore dispositions as they relate to imperatives for professionalization.

Obligation to Act in the Interest of Public Well-being - Broadly, mindset may be most relatable to ethics. Many associations that arise to attend to the well-being of a profession, such as the Association for Information Systems, Association for Computing Machinery, and Institute of Electrical and Electronics Engineers, provide a codification of ethics. These are necessary to establish both the normative and cultural aspects of professionalization. Further, these associations often become involved in the regulative elements. Gotterbarn and Miller (2009) provide a compelling exploration of the facilities of codes of ethics for professional practice in computing.

Despite these measures, we propose that these codes have yet to achieve the imperatives that ensure obligation. There is not a code of ethics anywhere that, alone, will ensure that errant behavior is addressed and corrected. Other elements reflective of an institutionalized profession must also be brought to bear: at a broad level, regulation, and at an individual level in cognitive and cultural dimensions. The number of parables, exemplars, and vignettes of the consequences of errors in computing is not sufficient such that imperative for action is clear and present.

While there are lessons for a range of stakeholders, we scope our focus to what we, in the academic "arm" of the computing disciplines, can do to aid in institutionalization.

There are implications for various roles and perspectives within the academy, where professional societies, administrators, and faculty may each influence norms, regulations, and culture. To achieve the same level of transparency that exists in our nutrition labeling example, we focus first on achieving transparency in curriculum design as clarity benefits each stakeholder. If we accept that facilitating processes of institutionalization create the ultimate imperative to act within the public interest (Gotterbarn & Miller, 2009; Gray, 2015), then the curricula we design does matter.

7. CONCLUDING REMARKS

In academia, our role remains the comprehensive and holistic preparation for professional endeavor via the education environment we provide in our institutions. In this charge, we have an opportunity to improve communication with stakeholder groups such that we are clear on the product that arises from our process. The articulation and execution of our curriculum, in various pedagogical modes appropriate to our circumstances and proclivities, is our stock in trade and forms the basis of our reputation. Whereas it may be sufficient to rely on other reputational signals at the institutional level, our most profound reputation is manifest in the subsequent journey our alumni forge. Rather than have the public believe this was the result of mysterious alchemy, situated in broad terms such as "IT, Security, or Project Management," we are at an inflection point where transparency will best serve the public interest. This is not to say that the public uses extensive and acute knowledge about the mature professions daily. Rather, the public trusts the mature professions and their institutions since their practices can be verified and updated, as necessary.

While the impact of computing on society, and thus on public well-being, is not disputed, our obligations to society are less clear. The elements that would accelerate the institutionalization of computing professions are known, but the catalyst that would cement these is lacking. Our audience here is our colleagues in higher education, and specifically within the information systems discipline.

There is a call for us to heed in the competency model promulgated within recent curriculum modeling efforts (Clear & Parrish et al., 2020; Leidig & Salmela et al., 2020). That call is to explore elements beyond knowledge and skills and forge into the realm of factors that shape competent and professional behavior that is worthy of respect and trust. In this manner, we have our reputation to protect such that our value proposition remains intact. Although often tacitly acknowledged, our value proposition must be explicated to include a broad preparation for professional practice that includes shaping of mindset. The value of our programs includes not only lucrative compensation for the profitable application of computing knowledge and skills, but the additional shaping of dispositions that is often, and colloquially, known as "character." Mindset and habit, perpetuated in lifelong learning through reflective practice, must accompany the application of knowledge and skills and must be molded explicitly in obligation to public well-being.

The competency model asserts that the shaping of mindset, dispositions, and habits is not out of scope, but rather is required. This is undoubtedly messy and controversial territory, but the imperative here is not to teach students what to think, but how to think, such that their competent professional practice is fully informed in the critical aspects of accountability: risk, responsibility, and consequence. Each transaction between task and competent execution to accomplish a task brings about the need for accountability to meet the obligations of professional practice. It is our charge to develop curricula that transparently satisfy this imperative. Furthermore, exploration of the processes of institutionalization is warranted to support our ability to mature as a discipline and to act in service to public well-being.

Understandably, some will ask a valid question here: but why do we need this? Whilst the societal impact imperative has been provided, a more concrete appeal may be in response to extant calls for increased professionalism from within the realm of practice. As a pragmatic matter, Bob Martin (2011) is among advocates for the orientation that competencies can deliver. Whilst it will not likely be the case that all practitioners will enter into the technology workforce as college graduates, among the benefits of a baccalaureate program in computing could be this vital facet of the ethical imperatives that most societies and accreditors espouse and require. The public can better understand the value that computing provides to society with this leadership.

This paper has been a call and exploration of professionalism precipitated by the renewal of a competency basis for curriculum design that has arisen from both the CC2020 and IS2020 projects and reports. Among the premises for a competency-based approach is the degree to which competencies explicate expectations and verify their fulfillment. It is no longer permissible to continue to treat the societal byproducts of computing as being akin to mystery – certainly not for the public perception. There is a clarity in a competency's articulation not dissimilar to what nutrition information on packaged food conveys: what to expect and in what measure. We extrapolate from the opportunities presented within a competency-based approach to also push forward exploration and dialog on the matter of professionalizing the computing disciplines. If a competency-based articulation of computing curricula increases opportunities for clarity and accountability, we advocate that these maturing aspects be extended to the contracts and understandings we establish at a societal level, inherent in the execution of these competencies.

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Appendix A — CC2020 Landscape of Computing Knowledge

		CE		CS		CSEC		IS		IT		SE	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
1. Users and Organizations	1.1. Social Issues and Professional Practice	2	5	2	4	2	4	3	5	2	4	3	5
	1.2. Security Policy and Management	1	3	2	3	4	5	2	3	2	4	2	4
	1.3. IS Management and Leadership	0	2	0	2	1	2	4	5	1	2	1	2
	1.4. Enterprise Architecture	0	1	0	1	1	2	3	5	1	3	1	3
	1.5. Project Management	1	3	2	3	1	2	4	5	2	3	2	4
	1.6. User Experience Design	1	3	2	4	1	3	2	4	3	4	3	5
2. Systems Modeling	2.1. Security Issues and Principles	2	3	2	3	4	5	2	4	3	4	2	4
	2.2. Systems Analysis & Design	1	2	1	2	1	2	4	5	1	3	2	4
	2.3. Requirements Analysis and	1	2	1	2	0	2	2	4	1	3	3	5
	2.4. Data and Information Management	1	2	2	4	2	3	3	5	2	3	2	4
3. Systems Architecture and Infrastructure	3.1. Virtual Systems and Services	1	3	1	3	1	2	1	2	3	4	1	3
	3.2. Intelligent Systems (AI)	1	3	3	5	1	2	1	2	1	2	0	1
	3.3. Internet of Things	2	4	0	2	1	3	1	3	2	4	1	3
	3.4. Parallel and Distributed Computing	2	4	2	4	1	2	1	3	1	3	2	3
	3.5. Computer Networks	2	4	2	4	2	4	1	3	3	4	2	2
	3.6. Embedded Systems	3	5	0	2	1	3	0	1	0	1	0	3
	3.7. Integrated Systems Technology	1	2	0	2	0	2	1	3	3	4	1	3
	3.8. Platform Technologies	0	1	1	2	1	2	1	3	2	4	0	2
	3.9. Security Technology and	2	3	2	4	4	5	1	3	2	4	2	4
4. Software Development	4.1. Software Quality, Verification and	1	3	1	3	1	2	1	3	1	2	3	5
	4.2. Software Process	1	2	1	3	0	2	1	3	1	3	3	5
	4.3. Software Modeling and Analysis	1	3	1	3	1	2	2	4	1	3	4	5
	4.4. Software Design	2	4	2	4	1	3	1	3	1	2	4	5
	4.5. Platform-Based Development	0	2	2	4	0	1	1	3	2	4	1	3
5. Software Fundamentals	5.1. Graphics and Visualization	1	2	2	4	0	1	1	1	0	1	0	2
	5.2. Operating Systems	2	4	3	5	2	3	1	2	1	3	1	3
	5.3. Data Structures, Algorithms and	2	4	4	5	1	3	1	3	1	2	2	4
	5.4. Programming Languages	2	3	3	5	1	2	1	2	1	2	2	3
	5.5. Programming Fundamentals	2	4	4	5	2	3	1	3	2	4	3	5
	5.6. Computing Systems Fundamentals	2	3	2	3	1	2	2	3	1	3	2	3
6. Hardware	6.1. Architecture and Organization	4	5	3	4	1	3	1	2	1	2	1	3
	6.2. Digital Design	4	5	1	2	0	2	0	1	0	1	0	2
	6.3. Circuits and Electronics	4	5	1	2	0	1	0	1	1	2	0	1
	6.4. Signal Processing	3	4	0	1	0	2	0	1	0	1	0	1

Table 3: Landscape of Computing Knowledge (Clear & Parrish et al., 2020)

It is worthwhile to note the data represented in this appendix and Appendix B record only opinion, albeit respected opinion. Note also that the CC2020 competency model is designed to support empirical curriculum data derived from competency specifications.

Appendix B — CC2020's Interpretation of Average Treatment by Subdiscipline Knowledge

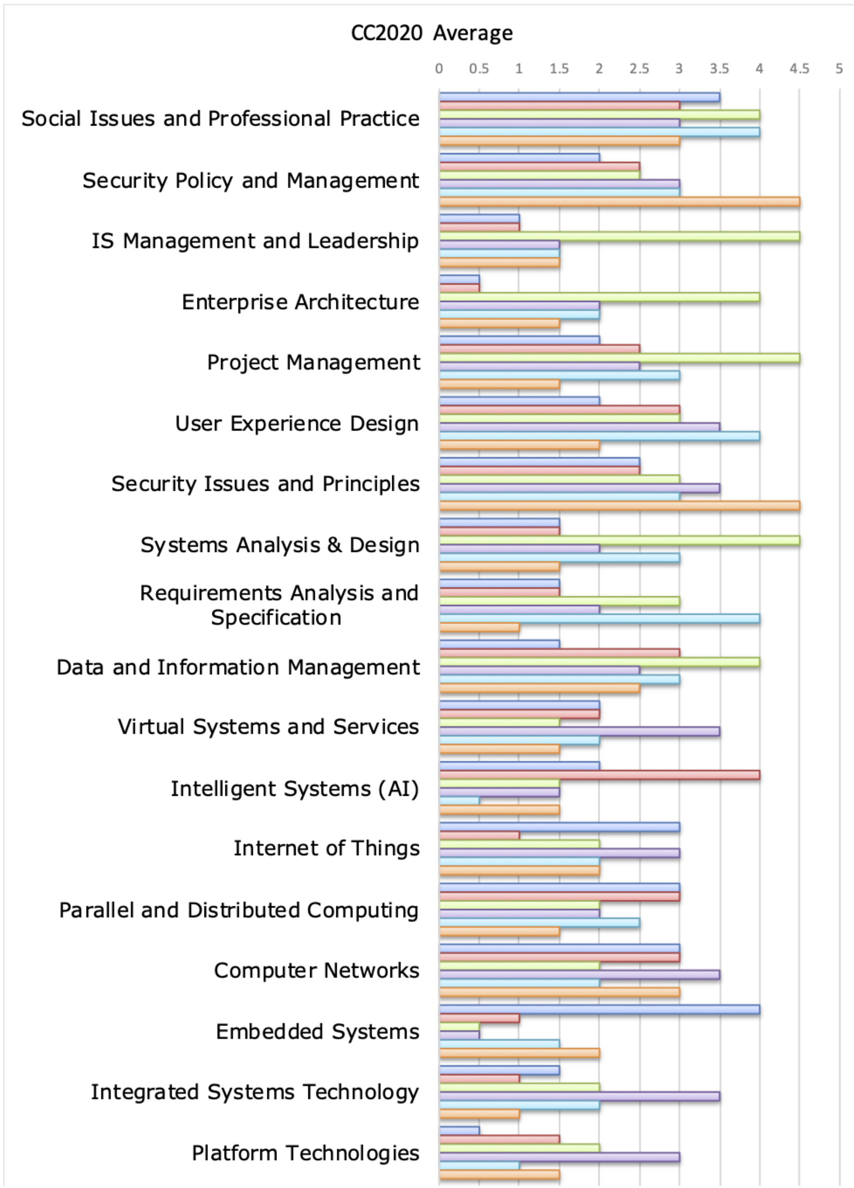

Figure 7: CC2020's Interpretation of Average Treatment by Subdiscipline Knowledge

It is worthwhile to note comparison presented here only reflects opinion, albeit respected opinion. The CC2020 competency model is designed to support empirical data derived from subdiscipline guidelines' constituent competencies, institutional program descriptions, and job descriptions; specifically, to facilitate intra- and inter-competency comparison. (This graph detail is more easily examined enlarged on your PDF reader application rather than in print.)

Appendix C — Revised Bloom's Taxonomy, Including Action Verbs (Anderson & Krathwohl, 2001)

Definitions	I. Remembering	II. Understanding	III. Applying	IV. Analyzing	V. Evaluating	VI. Creating
Bloom's Definition	Exhibit memory of previously learned materials by recalling facts, terms, basic concepts, and answers.	Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.	Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.	Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.	Present and defend opinions by making judgments about information, validity of ideas, or quality of work based on a set of criteria.	Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.
Verbs	• Choose • Define • Find • How • Label • List • Match • Name • Omit • Recall • Relate • Select • Show • Spell • Tell • What • When • Where • Which • Who • Why	• Classify • Compare • Contrast • Demonstrate • Explain • Extend • Illustrate • Infer • Interpret • Outline • Relate • Rephrase • Show • Summarize • Translate	• Apply • Build • Choose • Construct • Develop • Experiment • Identify • Interview • Make use of • Model • Organize • Plan • Select • Solve • Utilize	• Analyze • Assume • Categorize • Classify • Compare • Conclusion • Contrast • Discover • Dissect • Distinguish • Divide • Examine • Function • Inference • Inspect • List • Motive • Relationships • Simplify • Survey • Take part in • Test for • Theme	• Agree • Appraise • Assess • Award • Choose • Compare • Conclude • Criteria • Criticize • Decide • Deduct • Defend • Determine • Disprove • Estimate • Evaluate • Explain • Importance • Influence • Interpret • Judge • Justify • Mark • Measure • Opinion • Perceive • Prioritize • Prove • Rate • Recommend • Rule on • Select • Support • Value	• Adapt • Build • Change • Choose • Combine • Compile • Compose • Construct • Create • Delete • Design • Develop • Discuss • Elaborate • Estimate • Formulate • Happen • Imagine • Improve • Invent • Make up • Maximize • Minimize • Modify • Original • Originate • Plan • Predict • Propose • Solution • Solve • Suppose • Test • Theory

Table 4: Revised Bloom's Taxonomy, Definitions, and Action Verbs (Anderson & Krathwohl, 2001)

Appendix D — Candidate Dispositions from The CC2020 Report

Disposition	**Elaboration,** adapted from (Baron & Kenny, 1986; Clear, 2017; Gray, 2015; Nwokeji, Stachel, Holmes, 2019)
Proactive	*With Initiative* / *Self-Starter* Shows independence. Ability to assess and start activities independently without needing to be told what to do. Willing to take the lead, not waiting for others to start activities or wait for instructions.
Self-Directed	*Self-motivated* / *Self-Directed* Demonstrates determination to sustain efforts to continue tasks. Direction from others is not required to continue a task toward its desired ends.
Passionate	*With Passion* / *Conviction* Strongly committed to and enthusiastic about the realization of the task or goal. Makes the compelling case for the success and benefits of task, project, team or means of achieving goals.
Purpose-Driven	*Purposefully engaged / Purposefulness* Goal-directed, intentionally acting and committed to achieve organizational and project goals. Reflects an attitude towards the organizational goals served by decisions, work or work products. *e.g.,* Business acumen.
Professional	*With Professionalism* / *Work ethic*. Reflecting qualities connected with trained and skilled people: Acting honestly, with integrity, commitment, determination, and dedication to what is required to achieve a task.
Responsible	*With Judgement* / *Discretion* / *Responsible* / *Rectitude* Reflect on conditions and concerns, then acting according to what is appropriate to the situation. Making responsible assessments and taking actions using professional knowledge, experience, understanding and common sense. E.g., Responsibility, Professional astuteness.
Adaptable	*Adaptable* / *Flexible* / *Agile* Ability or willingness to adjust approach in response to changing conditions or needs.
Collaborative	*Collaborative* / *Team Player* / *Influencing* Willingness to work with others, engaging appropriate involvement of other persons and organizations helpful to the task. Striving to be respectful and productive in achieving a common goal.
Responsive	*Responsive* / *Respectful* Reacting quickly and positively. Respecting the timing needs for communication and actions needed to achieve the goals of the work.
Meticulous	*Attentive to Detail* Achieves thoroughness and accuracy when accomplishing a task through concern for relevant details.
Inventive	*Exploratory / Inventive* Looking beyond simple solutions. Examining alternative ideas and solutions; seeks, produces, and integrates appropriate alternatives.

Table 5: Prospective Dispositions Summarized in The CC2020 Report (Clear & Parrish et al., 2020)