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Competency Modeling Mindset Skills within Human-Centered Design and Development

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ABSTRACT

This study will examine the application of competency-based modeling in collegiate human-centered design and development (HCDD) programs. Competency-based models are "collections of knowledge, skills, abilities, and other characteristics (KSAOs) that are needed for effective performance in the jobs in question" (Campion et al., 2011)**.** Currently, competency-based models have been applied heavily to fields such as human resource development, medicine, and healthcare (Tang and Cheng, 2017). These fields naturally lend themselves to this manner of learning because professionals either exhibit competencies or do not. The application of competency models to technology and, to an extent, HCDD has been a slower transition. This is because many of the skills within these professions are more challenging to assess. There have been competency-based models created to evaluate hard skills as well as soft skills since they are readily observable. However, current research falls short in applying competency models to the mindset skills that are just as important in the field of HCDD.

The research will explore how competency models can measure the development of mindset skills. Mindset skills relate to the concepts of computational thinking within HCDD. They are best described as a mindset that, while not technical in nature, aid programmers in code design and development. Mindset skills within HCDD serve as the bridge between hard and soft skills within HCDD. This allows programmers to solve problems from a multi-faceted point of view. They will not simply be approaching issues from a soft or hard skill frame of mind. Instead, those skills will be combined by utilizing mindset skills, which will take them to a higher level of critical thinking. As a result, individuals who master these skills discover analytical and creative solutions to technical problems.

By developing a best-practices competency model for mindset skills within HCDD, this research will serve as a model for mindset skills that can be implemented in future classrooms. Since there is little current application of competency modeling within HCDD, strategies, and techniques will be derived and adapted from related fields. This thesis will thus employ secondary research as the primary data collection method. Researching the effectiveness of previous competency modeling strategies will better inform the success of this competency model as applied to HCDD.

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Chapter 1

Introduction

As society becomes more reliant on technology, a natural consequence has been the rise in students looking to enter this growing industry. Specifically, interest in the field of human-centered design and development (HCDD) has grown considerably in this age of technology. This field endeavors to bridge the gap between users and systems, and it focuses mainly on the interactions between people and technology (Burgess, 2019a).

HCDD is currently one of the fastest-growing fields, and as users spend more time on their devices, they desire better cohesion between their intent and technical execution (Churchill et al., 2016). In other words, users want their devices to act as an extension of themselves, seamlessly allowing them to accomplish tasks.

The field of HCDD is technical in nature because it encompasses the design and development of computer applications and systems. However, professionals in this industry must possess strong, soft skills and cognitive thinking abilities (Churchill et al., 2016). Understanding users' needs is an essential skill in this industry so that designs meet the needs of audiences. A combination of both hard and soft skills, as well as computational thinking prowess, are required to succeed in this field. In an area that places equal focus on people and technology to drive innovation, it follows that both skills are needed in equal measures. However, that simply is not enough. Professionals in this field also need "to develop investigative, analytical, technical, communication, and advocacy skills to help shape the interactive technologies that augment people's abilities…" (Churchill et al., 2016). This is where mindset skills come into play. These skills allow developers to comprehensively approach problems and dynamically create lasting solutions.

This thesis will examine the applications of the competency-based modeling system within the field of human-centered interaction. Competency-based models are "collections of knowledge, skills, abilities, and other characteristics (KSAOs) that are needed for effective performance in the jobs in question" (Campion et al., 2011). Simply put, competency models are how managers, supervisors, or individuals themselves can measure performance success. Success is measured by achieving competencies, which are core skills specific to a job, course, or company.

This research will explore how competency modeling can be applied to the development of mindset skills in collegiate HCDD courses. Mindset skills cannot be classified as hard or soft skills. These skills fill the gap between hard and soft skills, and they relate to the knowledge behind abstract creative thinking. These traits can be described best as a mindset that combines the creative and the technical while adding additional layers of critical thinking. Mindset skills provide developers with a holistic overview of problems to develop comprehensive solutions.

Currently, competency-based models have been applied heavily to medical fields and HR due to the abundance of visually apparent competencies evident (Tang and Cheng, 2017). The application of competency models to HCDD has been a slower transition, and even then, they only apply to hard or soft skills. The current research falls short in applying competency models to less visual mindset skills. This thesis will apply the competency-based modeling system to the field of HCDD in order to aid students in developing and mastering mindset skills. In doing this, the research will suggest competency measurements and standards that should be implemented at the collegiate level to best measure student success.

This thesis examines how competency-modeling can be applied to mindset skills within Human-Centered Design and Development. To achieve this, this thesis is broken into several chapters. The first focuses on the current state of competency-based education. This section synthesizes the existing literature available and applications of the competency-modeling system. The next chapter examines the methods employed within this thesis and how secondary research approaches are utilized. From there, we will discuss different variations of skills within HCDD. This serves to inform the creation of this new area of mindset skills. The next chapter presents a competency-based framework to measure mindset skills. The approach for creating this model has been derived from the systematic review of current best practices. Finally, the last two chapters present future work in this field of study and conclude the thesis.

Chapter 2

Development of Competency-Based Education

Introduction

Competency-based education (CBE) is not a new concept by any means. While the system has roots that date back to the 19th century, the CBE movement gained traction in the 1970s through support from the US Department of Education (Gallagher, 2014). During this time, there was a push to revitalize and improve postsecondary education. Through the enactment of the Fund for the Improvement of Postsecondary Education (FIBSE), the government tried to "make higher education more efficient, economical, and relevant to students' lives, particularly their work lives" (Gallagher, 2014). The goal of this fund was to implement competency-based education in collegiate classrooms to develop programs that better prepare students for the professional workforce. To achieve this goal, institutions were given funds to restructure courses around competencies and students' performances concerning them (Gallagher, 2014). This shift in educational assessment standards back in the 1970's served as the foundation for the competency-based education systems of today.

With the 1970's CBE movement as a framework, the 21st century brought this modeling system back into the spotlight, especially at the collegiate level (Nodine, 2016). This resurgence in CBE reached new heights in 2014. By the fall of that year, the United States Department of Educated reported that roughly 600 public postsecondary colleges and universities were in the process of "designing or implementing CBE programs" (Mitchell, 2015). The past several years have shown many of those programs come to fruition, making competency-based education a staple of many college departments.

Competency-based education has been described as a “new way of organizing student learning in higher education” (Gallagher, 2014). This sentiment can be seen through the following examples, which will showcase foundational works in CBE and current applications of this system at the educational and professional levels. Through studying current literature in the field of competency-based education, we can synthesize what best practices are being utilized in the field currently.

Foundational Works

Given that competency-based education has been around for over 50 years, it follows that best practices have been established within the system. Although applied throughout many fields, CBE has its own set of terminologies and not domain-specific standards. These standards have been refined over the course of many years and studies.

The practice of competency based-education utilizes specific vocabulary when referring to certain practices, so it is important to distinguish some key terms. Most of the terms are used to fit within a hierarchical structure that gets increasingly specific the further down you go (Figure 1.). At the top, there is the general competency framework, which describes in broad terms how the system can be integrated within an existing organization. From there, competency models are slightly more specific. These consist of a “collection of competencies that are relevant to performance in a particular job” (Campion et al., 2011). In this thesis, the competency model will focus on a collection of competencies pertaining to the performance of mindset skills within HCDD. As shown in Figure 1, competency models are composed of competency dimensions, otherwise called sub-competencies. Sub-competencies make up competencies by breaking them down into smaller components. More will be said about the relationship between competencies and sub-competencies later in this section. Lastly, competencies, and sub-competencies, by extension, can be classified through behavioral indicators. These indicators are visual actions that denote the skill and performance level required to complete a given competency. Behavioral indicators are specific to each sub-competency; thus, they are the most specific detail under the competency framework umbrella.

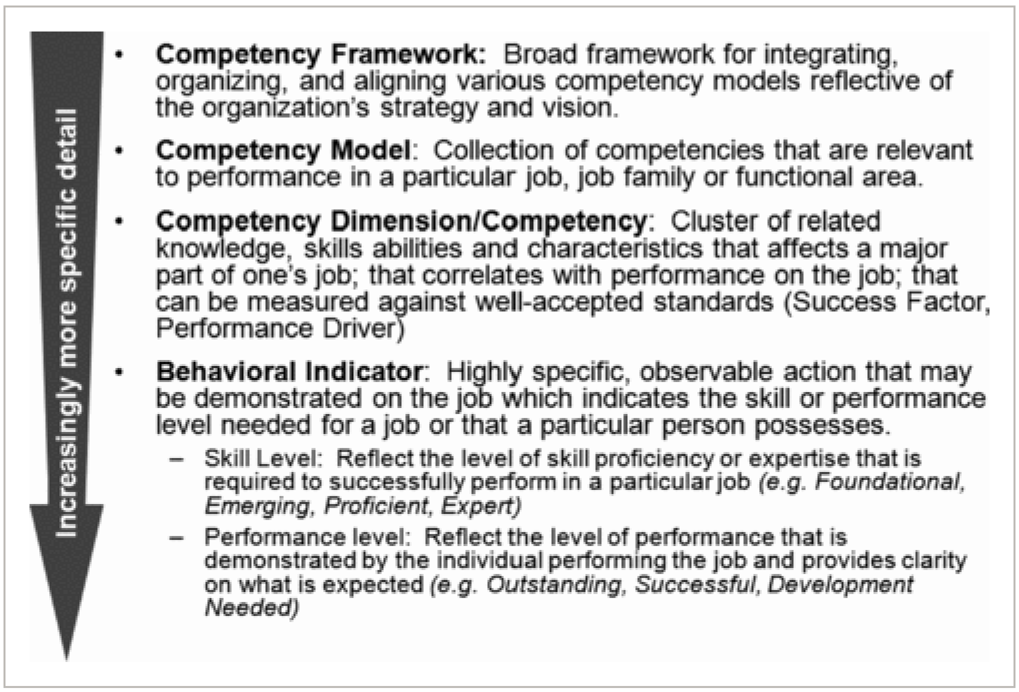

Figure 1. Terms to Define Competencies (Campion et al., 2011)

Now, with a general vocabulary to describe competency frameworks, we can discuss the difference between competencies and sub-competencies. While this is not always the case, often "competencies can be hierarchically arranged, meaning they can be divided into categories and subcategories" (Campion et al., 2011). These subcategories are typically referred to as sub-competencies. Sub-competencies are used to break complex competencies into smaller, more easily observable skills.

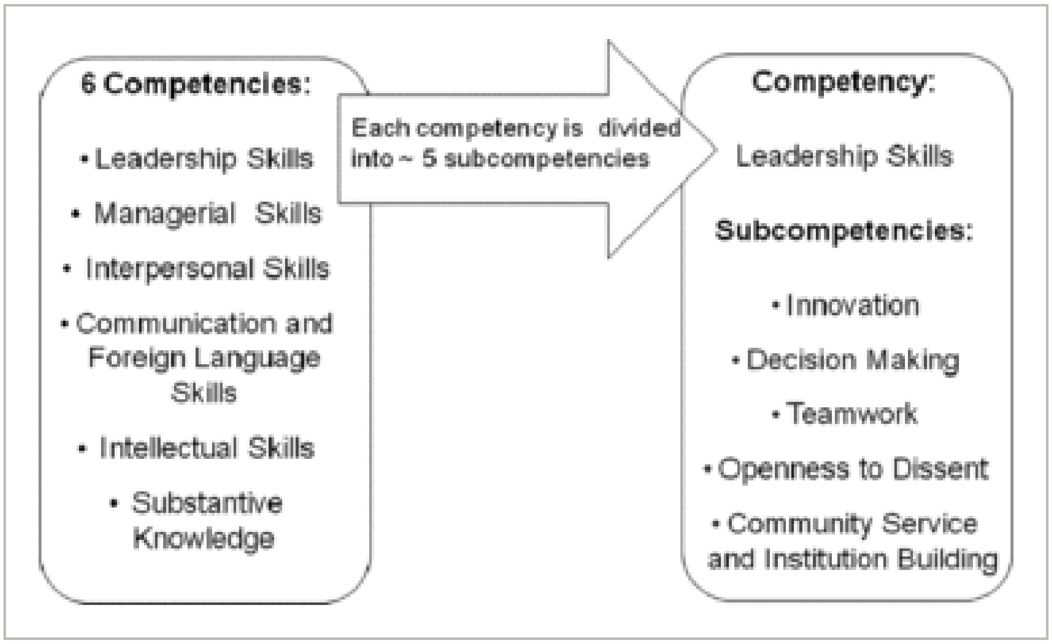

Figure 2. Competencies and Sub-competencies Illustrated (Campion et al., 2011)

As shown above, in Figure 2, there are six main competencies listed on the left. These skills are rather abstract and challenging to observe readily in a work or school environment. As a result, we can see that the competencies can be broken down into sub-competencies. Figure 2 depicts the breakdown of the Leadership Skills competency into five sub-competencies. From there, it is much easier to assess if an individual has mastered a competency since you can look to their acquisition of the corresponding sub-competencies as a clear indicator of skill.

Fields Related to HCDD

To make an effective competency model for mindset skills within HCDD, it is valuable to examine models from related fields. Arguably, one of the most comparable fields to Human-Centered Design and Development is User-Centered Design. User-centered design is a practice that focuses on how users interact with environments and technologies. This contrasts with human-centered design, which seeks to understand the full point-of-view of people in every aspect of the design and development process (Gasson, 2003). These words are often used interchangeably. But, while they both put users at the forefront of the design process, the fields are distinct and utilize different terminology.

While competency-based education has not been applied heavily to HCDD, there have been greater applications of this system within UCD. Competency modelling in user-centered design has been shown to boil down to the simple point that practitioners must understand both people and designs (Nieminen, 2015). That might sound relatively simple; however, people are inherently complex, and designing systems for them is no easy feat either. Competency modelling in UCD, as a result, must incorporate competencies that lead to the acquisition of those major goals.

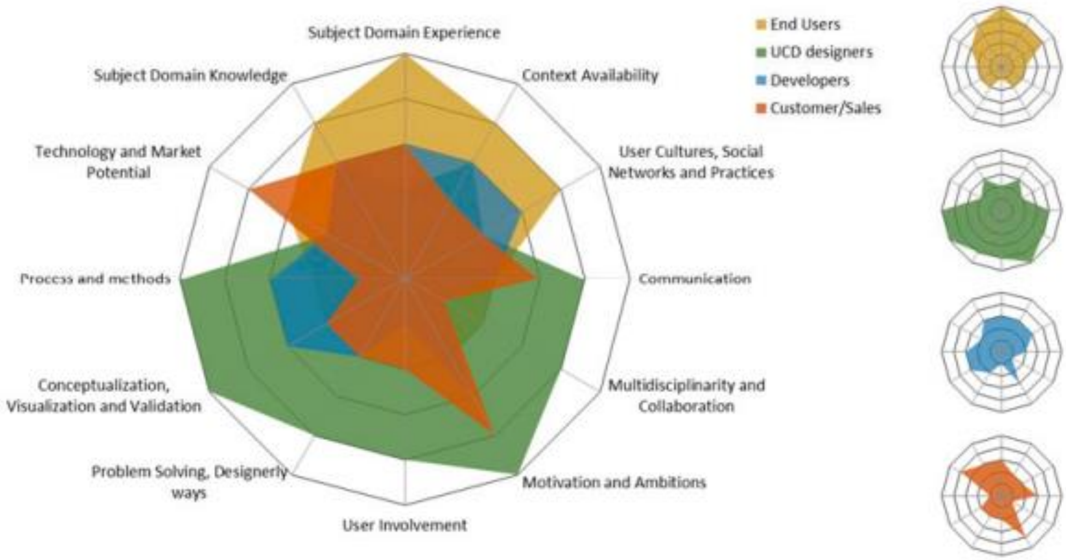

Figure 3. Visualization of The UCD Competency Model (Nieminen, 2015)

In order to better understand how UCD practitioners achieve their deep understanding of people and designs, it is helpful to look at the sub-competencies that make up those goals. The model shown in Figure 3 defines necessary collaborative, creative, and technical competencies within UCD. This model, in particular, does not focus on any specific job role or title. These competencies serve as high-level skills that any professional within UCD should achieve. The competency model does this by framing competencies in terms of the major stakeholders in any system: end-users, UCD designers, developers, and customers (Nieminen, 2015). In doing this, it is clear that these competencies were created to ensure that practitioners meet the needs of every group that interacts with the given system.

The model depicted in Figure 3 is important in how it comprehensively provides a competency-based evaluation system for skills within User-Centered Design. While UCD and HCDD are not entirely the same, they are closely related interdomain fields. Both lines of work serve users through the design and development of technical solutions. The similar field of focus between these two fields supports the creation of the competency model in this thesis, which will focus on mindset skills within HCDD.

Hard Skills in HCDD

In a field such as Human-Centered Design and Development, hard skills are typically what are emphasized the most in the classroom. Hard skills are distinguishable and observable skills that can easily be measured and validated (Oxford Reference, n.d.). Because HCDD is an interdisciplinary field that applies concepts and practices from other domains, experienced practitioners accumulate many hard skill competencies.

In HCDD, being able to design systems is critical. With this in mind, it is no surprise that students in this field should understand the “science, engineering, and design of graphical, visual, informational, and interactive [interfaces] for use by humans” (Blosch, 2020). As a result, practitioners should have an in-depth understanding of design systems, software, and practices, as well as knowledge of how humans perceive digital materials. This should manifest broadly in the hard skill of system design. This means that HCDD students should be able to develop conceptual designs, turn them into physical designs, and eventually transform those ideas into prototypes (Fawcett, 2021). Then, in turn, students must turn these designs into tangible interfaces and systems that users can interact with.

In a computer-oriented field such as this, hard skills are mainly classified as a technical skillset. For the development portion of HCDD, computer programming is a prominent component of the required skill-set. Programming is a broad category, and it can easily be broken into many sub-skills and competencies. For example, executing a loop or conditional statements would both be readily observable hard skills that a programmer should know. However, for the sake of HCDD hard skills, and because programming is only one component of this skill set, I will not delve deeper into all the sub-competencies required here. For HCDD students and professionals alike, being able to speak the language of programming while also maintaining a user-centered mindset is of the utmost importance (Churchill et al., 2013). Even when executing hard skills within this field, students must always keep their users and usability in mind.

Soft Skills in HCDD

While sometimes overlooked, soft skills within HCDD are just as important as their hard counterparts for any practitioner in this domain. Soft skills are the "intangible assets" that compromise how individuals interact with others and situations around them (Gulati and Reaiche, 2020). These skills are not technical in nature and, instead, focus on interpersonal communication and interactions.

Within hard skills, we discussed the design and development portions of HCDD. However, half of this field focuses on human-centeredness. Design and development would be minimally useful if it were not done through a humanistic lens. With this in mind, it is important that HCDD students understand others, not only their users but their teammates and collaborators as well. This might come in the form of empathy, being able to "feel for your users and for your team and for your business" (Burgess, 2019b). One of the traits that distinguish humans from machines is their capacity for genuine emotions and compassions. It is important that HCDD students can understand the needs of others and try to meet them.

HCDD is a collaborative field. Not only will students be expected to work with people with similar skill-sets, but it is entirely possible that they are also put on mixed teams with those from different backgrounds. Collaboration is key since this field requires the "participation of project team members for organizing design tasks and sharing experience and information" (Delavari et al., 2011). With this in mind, HCDD practitioners should be well-versed in common collaborative soft skills. This might range from active listening to compromising and negotiation to conflict resolution and de-escalation. The common thread here is that in HCDD, students need to be able to work and communicate effectively with others.

Not only are collaborative skills necessary in HCDD, but soft skills also include the ability to present and express ideas. An idea is worth practically nothing if it is not shared with others. Since HCDD is a technical field, students should be well versed in translating their ideas into layman's terms. The systems that are designed and created by practitioners in this field are used by people from all different backgrounds. Additionally, as previously mentioned, it is common that someone in HCDD will be on an interdomain team, which means constant communication with individuals of varying backgrounds. With this in mind, students should be able to explain technical jargon in an accessible way (Delavari et al., 2013). Conveying ideas with eloquence to potential customers or stakeholders has the potential to make or break the success of a project since systems need the support of those parties.

Chapter 3

Methods

This thesis will utilize the secondary research method of systematic review as the primary data collection method. A systematic review entails that one "overviews, discuss(es), [and] critiques … previous work and the current gaps in knowledge" (Roth, 2022). Typically, this entails scouring related primary sources to demonstrate where current knowledge extends to and how it can be synthesized to meet a current need. Systematic reviews have a variety of uses within research. They can serve as a "comprehensive report" and "collate all that is known" regarding any particular review question (Roth, 2022). This methodology is most commonly used to show what work has previously been done within a field while also rationalizing the need for new research to address unanswered questions.

The systemic review method is not a new concept by any means. It has been utilized across many different fields and subject domains to analyze and synthesize data. In 2013, a team of researchers from the University of New South Wales in Sydney, Australia, conducted a systematic review of research evidence that supported the benefit of mental health smartphone applications (Donker et al., 2013). This review yielded the conclusion that mental health applications have the potential to be highly effective, but there is a current lack of scientific evidence to support these claims. The research provided a strong foundation for any future research in this domain by establishing what existing mental health applications can provide for patients with specific symptoms.

Systematic reviews can also be done in a manner that helps to compile and empirically evaluate data in fields where such information might not be apparent. Researchers from the conducted a systematic review of gamification in e-Health in 2017. This study was able to accomplish a systematic review that summarized current knowledge within gamification of eHealth (Sardi et al., 2017). Within the review, the researchers found the most commonly used gamification strategies as well as the benefits and shortcomings of this new trend. This research provided data that suggested the current short-term engagements effects of gamification, and it also made suggestions for how gamification could reach new heights. The systematic review offered these valuable insights to a new market that could help medical professionals and users alike make important decisions regarding eHealth gamification.

Research in this thesis will be done by synthesizing information from competency models within fields related to HCDD. The competency model data has been compiled from independent sources and studies. Since there is currently little to no competency model application within the given domain, this thesis will reference models from related fields. The models reviewed in the Literature Review will be used as guides to inform the creation of a new model that applies to mindset skills within HCDD. All of the work that will be referenced in this thesis will be assessed in terms of quality and its relevance to the subject area being studied. Studies that were included in this thesis relate to the subject area in one of three ways. The research was either conducted in a similar field to HCDD and included competencies related to mindset skills, or they served as general best practices for creating competency models. Eligibility was decided based on the contents of the research and the inclusion of the criteria listed above. The data collected through the systematic review will inform the competency model for mindset skills in HCDD created in this thesis.

The sources targeted for this review have applied competency models to their respective fields. The goal of this systematic review is to uncover best practices in competency modeling that can be utilized to create a model for mindset skills within HCDD. By systematically reviewing the current modeling techniques, the information synthesized will serve as a foundation and guideline as to how this competency model should be constructed.

Research Questions

Based on the research from the previous studies described in Chapter 2, it is evident that competency-based education has been widely used within the last 50 years. This system spans a multitude of domains and has clearly been applied to measure the acquisition of many different competencies within their respective fields. Although research demonstrates there has been margin application of competency-based education within HCDD, current studies are yet to explore the acquisition of mindset skills within this field. Because of this, two questions need to be explored throughout this thesis:

1. What are mindset skills within the field of Human-Centered Design and Development?
2. How can the competency-based education framework be used to model and measure mindset skills?
3. In what ways do mindset skill competencies differ from soft and hard skill competencies?

Chapter 4

Mindset and Related Skills within HCDD

Critical Thinking

While competency-based education does focus primarily on hard and soft skills, collaborative problem solving (CPS) has been studied to some extent. CPS is a joint effort between at least two people to coordinate their individual skills in order to create a solution together (Sun et al., 2020). CPS creates opportunities for cognitive thinking, comprehensive understanding, and high-level problem-solving. Collaborative problem solving is not specific to just one domain. CPS skills have been found to be generalizable to almost every field (Sun et al., 2020).

Since CPS has been shown to be so applicable to various domains, it follows that competency-modeling has been applied to measure these skills. The major facets of CPS competency models included: constructing shared knowledge, negotiation/coordination, and maintaining team function (Sun et al., 2020). These key competencies are applicable across all professional and educational domains and serve as a skeleton for how similar skills could be applied in a domain-specific manner. Regarding this thesis, collaborative problem solving is a key component of mindset skills. However, mindset skills go further in that they encompass the entire creative thinking process regarding HCDD, rather than just the collaborative component. These skills are heavily related to and encompassed within the mindset skills that will be explored in this thesis.

Since the field of HCDD is technical in nature, it follows that higher levels of computational skills would be required of practitioners. Computational thinking involves "solving problems, designing systems, and understanding human behavior by drawing on the concepts fundamental to computer science" (Wing, 2006). This line of thinking serves as a mental process of breaking down complex computational problems into understandable steps and algorithms. Computational thinking can be broken into six areas of focus:

> "(1) formulating problems in a way machines can solve, (2) processing data in a logical way, (3) representing data abstractly, (4) algorithmizing the automated solutions, (5) solving problems in an efficient way, and (6) transferring knowledge and skills in solving other problems" (Chen et al., 2017).

Together, these six steps create a level of looking at technical problems beyond just executing hard skills. Computation thinking requires that individuals fully understand problems in an abstract, technical, and logical manner. In doing this, computational thinking aims to achieve the most "efficient and effective" solution (Chen et al., 2017). While the roots of this idea come from computer science, the same can be said for HCDD. Through utilizing computational thinking, practitioners within HCDD can also strive to create efficient and effective high-level solutions with their users in mind.

Moving from computational to creative thinking, creative programming is another key aspect related to mindset skills within the field of HCDD. Creative programming is a subset of computational thinking, and it encompasses the ability to analyze problems, refine programs, and generally employ agile thinking in programming (Romero et al., 2017). Creativity, in this regard, can best be considered a process rather than something an individual intrinsically possesses. Through this lens, creativity, and by extension, creative problem solving, can be applied to programming. Computer programming is about more than just writing lines of code and compiling it. Programming also includes “the capacity to analyze a situation, identify its key components, model the data and processes, and create or refine program through an agile design-thinking approach” (Romero et al., 2017). This is where the ideas of creative programming come into play. Programmers, at their highest level, should be able to think past their next line of code. By utilizing creative programming strategies, programmers take their practice to a higher level, which in turn allows them to create systems that solve problems at a higher level.

The concept of creative programming incorporates how cognitive and metacognitive strategies can be utilized in order to come up with the best solutions to any given technical problem. To better understand creative programming, it makes sense to dive deeper into what cognitive and metacognitive skills are. Cognitive strategies allow individuals to “process and transform information into stable and dynamic knowledge structures” (McCrindle and Christensen, 1995). These skills are especially important when we are in the process of learning or retaining knowledge. However, they do not adequately cover the generalizability and awareness of knowledge required to solve complex problems. The answer to cognition’s shortcomings comes in the form of metacognition.

The concept of metacognition relates directly to that of cognition. The term metacognition was first introduced in 1976, and it is used as a way “to refer to knowledge and awareness of one’s cognitive processes and the ability to actively control and manage those processes meets” (McCrindle and Christensen, 1995). Essentially, metacognitive is a step above cognition in terms of awareness and levels of thinking. Metacognition encompasses the control and knowledge of when to utilize certain strategies and cognitive processes when completing a task.

The relationship between cognition and metacognition can best be described through an example. When studying for an exam, a student will access basic mental processes, such as accessing long-term memory, analyzing passages, or making comparisons between texts (Scanlon, n.d.). These are all cognitive processes that we employ every day in order to work, study, and complete tasks. Metacognition comes into play when we are faced with problems that are larger in scope. These skills would be used when planning an approach to complex problems or projects or assessing understanding of a material (Scanlon, n.d.). Metacognition includes our awareness of our knowledge and our capacity to think critically about what cognitive skills are needed to carry out a task.

The cognitive and metacognitive skills that individuals engage in creative programming are utilized throughout the creative programming process. By employing these strategies, developers who practice creative programming can plan solutions, structure their knowledge, and thoroughly execute their designs. These skills are integral to the formation of mindset skills within HCDD. Creative programming, as well as the cognitive and metacognitive awareness that it encompasses, is the hallmark of mindset skills. When applied to HCDD, developers will be able to creatively plan solutions for complex user-focused problems with their own cognitive skill sets in mind. This will allow for students within the field of HCDD to better design and execute creative solutions to the vast array of problems that they will face in their careers.

Mindset Skills in HCDD

HCDD is an interdisciplinary field that combines ideas from computer science, behavioral science, design, anthropology, psychology, and many other fields (Pursel, 2005).

Since students in this field are expected to have a diverse knowledge base, it only follows that their skill set should not merely be limited to hard, technical skills and soft interpersonal skills. There is an untapped middle-ground of skills that successful HCDD professionals employ, often without realizing it. This set of skills is called mindset skills.

Mindset skills can best be described as where soft and hard skills meet. They include the creative programming, computational thinking, and multi-faceted point of view that HCDD students and professionals are expected to employ. A successful individual in this field should not merely be a good coder and a competent collaborator. Technical skills should not be performed in isolation from their soft counterparts. Professionals in this field need to constantly be in a user-oriented mindset. This means that they should tackle all problems from a holistic point of view, where they interpret the problem both creatively and computationally. In doing this, those who practice HCDD can create solutions and systems that are technically and socially savvy.

As established in Chapter 2, there is currently no field of skills that meet these criteria in HCDD. Skills are differentiated in a binary fashion as either hard or soft. However, this rigid classification system is a disservice to students in collegiate HCDD programs. If mindset skills and creative, agile thinking are not taught in the classroom, students will not be well trained for the real world, where problems are often complex and solutions complicated. The case for creativity in HCI has been given several times, with a notable instance back in 2019. Researchers wrote, “HCI education needs to prepare the designers behind the creation of interactive systems to look beyond data-first paradigms, question established methods, and frame all that they do from the perspective of potential unforeseen consequences” (Groves and Fass, 2019). The same can be said for encouraging mindset skills in HCDD. Mindset skills should be included in the classroom in order to best prepare students for the high level of diverse thinking that they will be expected to meet in the workforce. These skills encourage students to think creatively and analytically to develop advanced solutions to all problems.

Chapter 5

Framework

This competency model is a framework for measuring the acquisition of mindset skills within the field of Human-Centered Design and Development. The framework is divided into competencies and sub-competencies for specific mindset skills within the field of HCDD. Each sub-competency is paired with a level in Bloom's Taxonomy, which indicates the level of thinking that is required of each corresponding sub-competency.

This model will serve as an indicator of whether or not students have mastered the core competencies. Attainment of core competencies will show if students have successfully mastered the intermediate skills required within the field of Human-Centered Design and Development. These competencies can be seen within the four major stages of the HCDD process: research/identification, ideation, design/development, and feedback. All of these stages contain mindset competencies for students to achieve. The competency framework below is formatted in a manner similar to *A Competency Model for Undergraduate Programs in Information Systems*, which was created by a joint task force put together by the Association for Computing Machinery (ACM) and the Association for Information Systems (AIS) (Leidig and Salmela, 2021). This competency model, discussed in more depth in Chapter 2, was used as the formatting framework for the competency model in this section. However, the content of the competency framework was created through a synthesis of best practices from the current competency modeling literature, as described in previous chapters.

The skill level for the sub-competencies within this framework was determined using Bloom's Taxonomy using the technique outlined below. Bloom's Taxonomy "classifies the different layers of learning processes that a student goes through when learning objectives are set for them" (Sivaraman and Krishna). Numerically, the higher the number associated with a competency, the higher order of thinking a task requires.

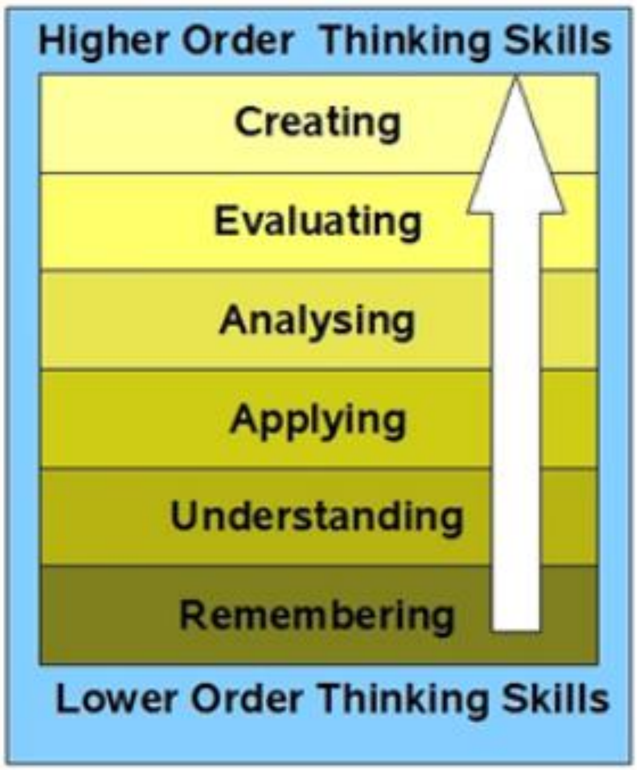

Figure 4. Bloom's Taxonomy Thinking Levels (Churches, 2008)

The orders of thinking associated with Bloom's Taxonomy can be seen in Figure 4 above. Since mindset skills tend to incorporate more advanced and applied ways of thinking, it follows that most of the sub-competencies require higher orders of thinking. Mastery of the following competencies will show that students have reached a level of computational thinking and that they have successfully blended soft and hard skills and achieved a new interdisciplinary skill-set.

The levels of Bloom's Taxonomy vary in complexity and skill level. With this in mind, the usage of specific key verbs can indicate what skill level is associated with different competencies or sub-competencies. Figure 5 represents what verbs map to each order of thinking. This mapping system was utilized to assign different Bloom's Taxonomy levels to each sub-competency within the mindset skills competency model.

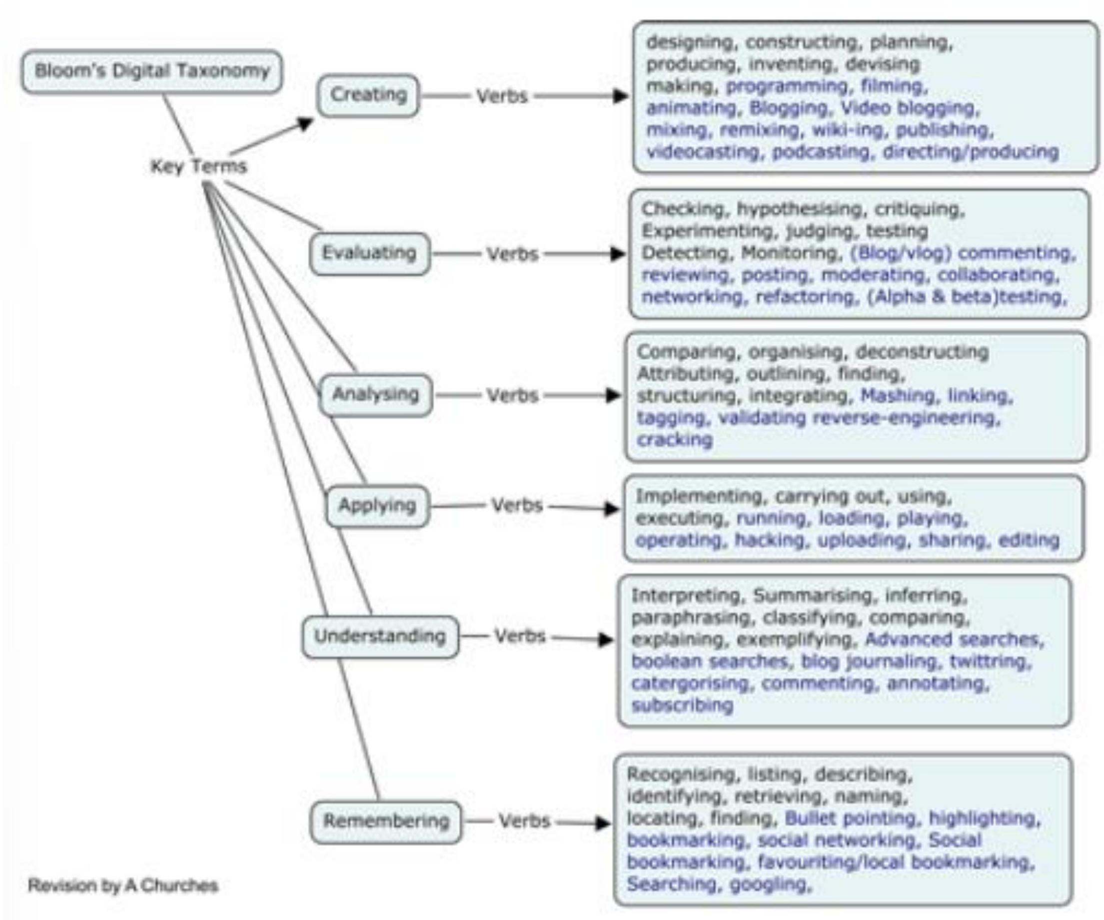

Figure 5. Digital Map of Bloom's Taxonomy (Churches, 2008)

Competency Area Statement

Students will demonstrate their achievement of mindset skills within the field of Human-Centered Design and Development through demonstration of the following competencies. Topics of mindset competencies include computational thinking, collaborative problem solving, creative programming, and cognitive and metacognitive processing. Mastery of these competencies, and their subsequent sub-competencies, will indicate a demonstration and execution of mindset skills within HCDD. The core competencies provided below were synthesized from the mindset and critical thinking skills presented in Chapter 4.

Core Competencies: Graduates of this program will be able to:

1. Demonstrate computational thinking
2. Solve problems collaboratively
3. Program creatively
4. Process information through cognitive and metacognitive means

Competency 1: Demonstrate computational thinking

Table 1. Competency Pairs for Competency 1

Sub-Competency	**Skill Level (Bloom's taxonomy)**
Interpreting problems in a machine solvable manner	2 - Understand
Organizing data logically	4 - Analyze
Constructing data in an abstract manner	6 - Create
Evaluating problems efficiently and effectively	5 - Evaluate

Competency 2: Solve problems collaboratively

Table 2. Competency Pairs for Competency 2

Sub-Competency	Skill Level (Bloom's taxonomy)
Constructing shared knowledge	6 - Create
Structuring team functions	4 - Analyze
Collaborating with teammates to effectively solve problems	5 - Evaluate
Critiquing work in a constructive manner	5 - Evaluate
Monitoring team function	5 - Evaluate

Competency 3: Program creatively

Table 3. Competency Pairs for Competency 3

Sub-Competency	Skill Level (Bloom's taxonomy)
Analyze problems in an abstract manner	5 - Analyze
Reviewing and refining programs throughout stages of design and development	4 - Evaluate
Programming and designing systems through an agile process	6 - Create

Competency 4: Processes information through cognitive and metacognitive means

Table 4. Competency Pairs for Competency 4

Sub-Competency	**Skill Level (Bloom's taxonomy)**
Process new information	2 - Understand
Interpret development roadblocks and errors	2 - Understand
Outline design and development solutions	5 - Analyze
Plan solutions to problems	6 - Create
Check your knowledge and understanding of development solutions	4 - Evaluate

Chapter 6

Moving Forward

This thesis serves as a framework and initial competency model for mindset skills within the field of HCDD. The model was created through a systematic review of previous literature related to the topic. This competency model serves as a current best practices framework for mindset skills based on a review of the existing literature available.

Moving forward, the next step would be to take this competency model and empirically test it within college HCDD courses. The experiment would study and evaluate the success of the competency model for mindset skills within HCDD at the collegiate level. Ideally, this would occur in the form of a semester-long experiment where some HCDD courses are presented with the competency model. In contrast, others continue using their traditional forms of student assessment measures. The students would have access to the models, and they would be encouraged to complete self-evaluations throughout the semester to track their own perceived achievement of core competencies. However, professors would also be measuring student success via the competency models when it comes to developing mindset skills. The goal of such an experiment would be to determine whether or not students are achieving these mindset skills throughout a semester-long HCDD course. This would allow students and faculty to consider how the students or course could change to better aid in the development of mindset skills in college.

Chapter 7

Conclusion

Competency-based modeling is a performance measurement system that has been used for years across various fields. The application of this practice to the field of Human-Centered Design and Development has been slow. Current competency models applied to HCDD only measure easily observable and technical hard skills or interpersonal and communicative soft skills. This thesis proposed the presence of a third group of skills, mindset skills, which are a bridge between the soft and the hard. This set of skills involves creative, computational thinking, and high-level problem solving while also maintaining a human-oriented mindset. To measure these skills in the collegiate setting, competency-based modeling can be used to outline key competencies, as well as sub-competencies, that students should demonstrate in order to prove that they have acquired these mindset skills. Using this competency model as a tool for HCDD courses to measure the acquisition of this skill might offer serious implications for both the success of the student and the effectiveness of the course as a whole.

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- Team: Automation team within IBM Z Systems
- Designed and executed internal software using Python and Robot Frameworks to parse security error logs
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- Developed a reporting system for trusted computing errors that is used internally by the entirety of System Z

June 2020 – August 2020

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