

Applying Millers Pyramid of Competence Assessment to an Online Health Informatics Curriculum

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An online Master's in Health Informatics program applied Millers Pyramid of Competence to analyze assignments, assessments and learning outcomes. Faculty defined competencies and mapped courses to these competencies. Goals were to focus the curriculum beyond being knowledge-based, to include skills and professional attitudes that employers are seeking. To assist informatics faculty in transitioning assignments and assessments to meet the newly defined competencies, a tool was developed that synthesized concepts from Blooms Taxonomy and Miller's Pyramid of Competence Assessment. Suggestions for future practice and research are also discussed.

Keywords: higher education, competency, assessment, curriculum evaluation, change management

INTRODUCTION

In 2018 the American Medical Informatics Association (AMIA) published the core competencies for applied health informatics education at the master's degree level (Valenta, 2018). These core competencies form ten knowledge domains and provide examples of the key components for competency: knowledge, skills, and attitudes. With these knowledge domains, accredited programs can prepare to meet new Commission on Accreditation for Health Informatics and Information Management (CAHIIM) accreditation requirements to define a set of competencies specific to the program and revise curricula to become competency driven. This effort requires analyzing course objectives, assignments and assessments to map the elements of each course back to the competencies that were defined.

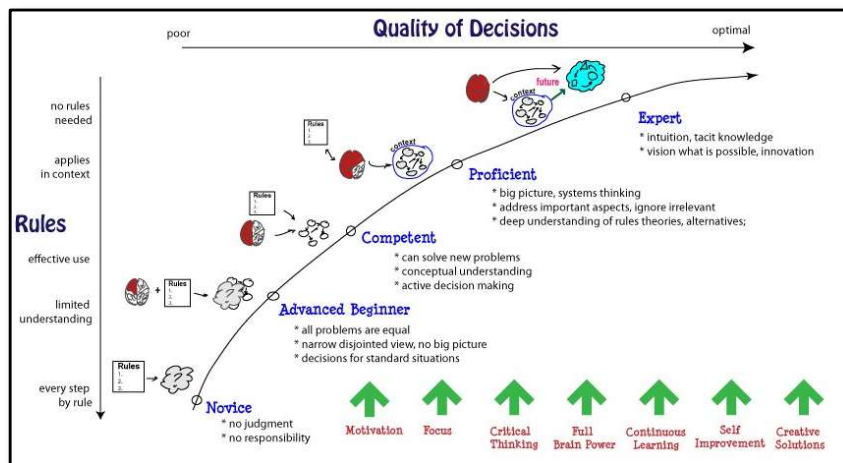
A two-year competency project was launched to meet new requirements for accreditation for the master's in health informatics program at the University of Illinois at Chicago. UIC launched the master's in health informatics (HI) program in 1999, delivered it in online format in 2006 and became the first accredited program in 2010. In 2020, UIC is still one of the largest programs of its kind with roughly 375 matriculating students and over 1000 graduates.

Although annual assessments of the program are completed to meet accreditation requirements, an in-depth analysis and mapping of the curriculum has not been undertaken since the program was originally accredited. Requirements to become competency-driven were published in 2018, therefore, this competency project represents the first time the UIC curriculum has been analyzed with this level of rigor in recent years. In addition to meeting CAHIIM requirements, the competency project afforded UIC the opportunity to address the maturing of the HI field by updating curriculum to remain relevant and improve the link between education and the 21st century healthcare labor market needs.

Goals of the competency project were defined to be: 1.) Innovate to transform the curriculum to meet the ongoing need for relevancy in the dynamic field of HI. 2.) Apply novel solutions to challenges of creating a competency-driven HI curriculum. 3.) Analyze the HI curriculum using an assessment and scaffolding tool that aligns Blooms Taxonomy and the Miller’s Pyramid of Assessment. 4.) Build competencies that go beyond knowledge to also include skills and professional attitudes that employers are seeking.

The effort encountered numerous challenges beginning with the need for faculty to learn competency-driven approaches themselves and then become ready to move to a new paradigm of student-centered active learning. This entailed professional development and education sessions for faculty guided by the curriculum steering committee. Then, the next task for faculty was to define the set of competencies for the UIC HI program. They discussed the question: Where does competence fall on a continuum going from novice to expert? The diagram in Figure 1 provided a starting point for these discussions. Faculty worked to arrive at a common understanding of how far the UIC program would go toward building knowledge, skills and professional attitudes for competence as defined for the UIC program and to translate it into course assessments that address the question, “When students graduate from the program, what will they be able to do?”. Once competencies were defined, faculty then moved into revising learning objectives, assignments and assessments in their courses.

FIGURE 1
DEFINING COMPETENT

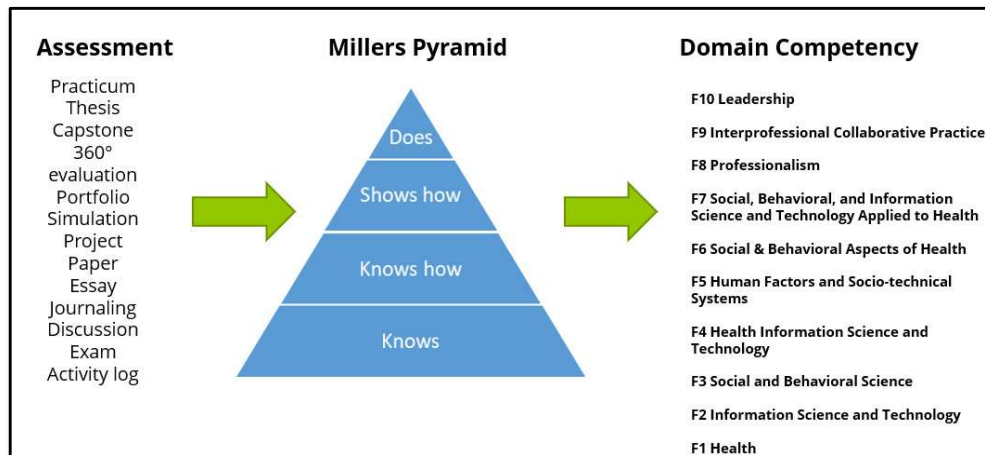


Source (adapted: Software Creation Mystery. (2009, April 6). How to become an expert. Top 7 qualities [Blog Post]. Retrieved from <http://softwarecreation.org/2009/how-to-become-an-expert-top-7-qualities/>

Theoretical Framework: Millers Pyramid of Competence Assessment

For the curriculum to become competency-driven, assignments and assessments must build knowledge, skills and professional attitudes, the three essential components of competency. Miller’s Pyramid of Assessment progresses from cognition, to behavior going from bottom to top, progressing through 4 stages defined to assess that students have demonstrated: Knowing, Knowing How, Showing How, and Doing. Miller’s Pyramid has provided a framework for assessing clinical competence in medical education (Ramani, 2008). This framework was applied by UIC faculty in each course to develop assignments and assessments aligned with expectations for what the learner will to do at each stage of the Miller’s Pyramid that meets one or more of the 10 AMIA knowledge domains (Figure 2).

FIGURE 2
ASSESSMENT OF COMPETENCY USING MILLER’S PYRAMID



Swirsky, E. (May 17, 2018). Curriculum Evaluation and Competency Assessment in Health Informatics. CAHIIM Accreditation Process Conference, Chicago, IL

METHODS

A series of events were designed and facilitated by the Curriculum Steering Committee to educate and prepare faculty to participate in activities to: define the current state, examine gaps in the curriculum, analyze assignments and assessments, and design a competency-driven curriculum (Table 1). In Phase 1, activities and tools were designed for use individually and in groups to work through the process. Faculty identified which knowledge domains their courses covered. This data was loaded into a spreadsheet providing the first draft of the current state of the curriculum. Gaps in knowledge domains revealed clues to be investigated further both at the individual course level and across the curriculum.

Next, faculty participated in workshops. During the workshops, faculty defined 17 competencies for the UIC program. Groups were formed to examine all courses contributing to a particular competency. Current assessments for contributing courses were analyzed and matched to the appropriate level on the Miller’s Pyramid. The workshop exercises revealed where additional assessments were needed. Faculty groups discussed which courses could add or change assessments to bolster competency areas that were lacking. Faculty then developed a course alignment table for each course that provided the next iteration of data for each course assessment including knowledge domain, Miller’s pyramid level and competency addressed. A work plan was developed outlining the tasks needed to reach each of the 17 competencies being covered by the required courses. Additionally, a rationale was developed for the role of elective courses in the curriculum. The result for Phase 1 was an iterative process of curriculum development, beginning at the course level, then proceeding to the knowledge domain level and finally reaching each of the 17 competencies at the curriculum level. As each step in the work plan was completed, competency mapping data was updated.

To support faculty through the curriculum development process, a new *Health Informatics Assessment and Scaffolding Tool* was developed to enable a view of competencies across courses (Figure 3). This view enabled faculty to devise the “scaffolding” of assessments that build to demonstrate competence. The Assessment and Scaffolding tool adapted and synthesized concepts from Blooms Taxonomy and the Miller’s Pyramid of Assessment (Krathwohl, 2002; Ramani, 2008). The tool was used to consider each UIC competency enabling faculty to establish assessments against the levels of Knows, Knows How, Shows How and Does and across courses simultaneously. This was then compared not just to the AMIA knowledge domain, but to the UIC defined competency (Figure 3). Actual assessments used in the courses were added to the tool to show what each course was contributing to meeting the competencies defined for the

knowledge domain. Thus, the Assessment and Scaffolding tool helped faculty to envision and map their assessments, to both the Miller’s Pyramid levels and the defined competencies. All data was entered into the CAHIM Self Evaluation Tool (CSET) heatmap tool producing a second draft of the curriculum mapping data (CAHIM, 2020).

**TABLE 1
COMPETENCY PROJECT EVENTS**

Phase 1	Fall 2018	3 Faculty Brown Bag sessions (education and professional development)
	Winter 2019	2 half-day workshops (write 17 competencies)
	Spring 2019	Develop the data on curriculum (analyze courses, develop course alignment tables)
	Summer 2019	Current State view of curriculum (input to heatmap tool)
	Fall 2019	Faculty begin changes/updates to courses (revise assignments and assessment)
Phase 2	Winter 2020	Review knowledge domain gaps (establish sub-workgroups)
	Spring 2020	Identify courses to fill curriculum gaps (examine assessments using scaffolding tool)
	Summer 2020	Revise courses (design new assessments)
	Fall 2020	Implement course changes (course development)
	Spring 2021	Updated HI Curriculum (final heatmap)

In Phase 2, the Curriculum Steering Committee established sub-workgroups to recommend solutions that would address two domains, F6 Social and Behavioral Aspects of Health and F10 Leadership, that were still not fully meeting the defined competencies. Workgroups developed options, negotiated on which courses would include the new assessments, and provided detailed recommendations for adding or revising assessments in several courses. The *Health Informatics Assessment and Scaffolding Tool* was used again to support faculty and provide data to guide revisions and confirm how the updates addressed the scaffolding gaps. Finally, workgroups met with faculty to design new assessments that, when aggregated with other courses, would enable faculty to observe students’ informatics competency through demonstration of their knowledge, skills, and attitudes. Another iteration of revisions and data collection were completed and entered into the CSET heatmap tool resulting in a final version of the curriculum mapping data.

To assist faculty in interpreting the data, an additional analysis was done to provide results for internal program use. A pivot table was developed to provide UIC with the flexibility to look at curriculum data by knowledge domain or UIC competency as well as by level of the Miller’s Pyramid.

FIGURE 3
HEALTH INFORMATICS ASSESSMENT AND SCAFFOLDING TOOL

HI Assessment for Competency F10#2	
Demonstrate behaviors and effective communication to motivate, direct and guide stakeholders, building collaborations throughout the organization and bringing resources to projects, programs, and people to accomplish a health informatics vision.	
Millers Pyramid	BHIS course and assessment
Does: assessed by activity being observed <u>in the context of professional application and practice</u> (ex: practicum experience, group project, giving a presentation or demo, role-based simulation, capstone project)	BHIS 5XX
Shows How: assessed by <u>application of a skill</u> or synthesis of a tool, framework, concept (ex: developing a presentation, data analysis visualization or interpretation, case study analysis, capstone paper)	BHIS 5XX
Knows How: assessed by <u>application of knowledge</u> tested by problem solving, explaining ideas or concepts (ex: write a critique of readings, discussion requiring description of examples, explanation, comparison; challenges, questions, or refutation of discussion content)	BHIS 5XX
Knows: tested by quizzes, writing, discussion that require recall of facts and concepts, processes, procedures	BHIS 5XX

1

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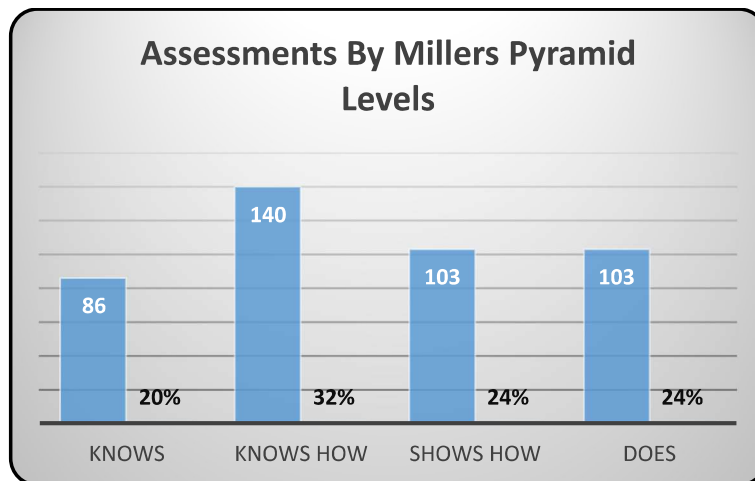
FINDINGS

Figures 4 through 7 show the frequency and distribution of assessments in the HI curriculum at the end of Phase 1 of the competency project.

Miller's Pyramid

A breakdown of all assessments by Miller's Pyramid level showed that assessments are relatively balanced across all four levels (Figure 4). The Knows level, representing foundational knowledge contained 20% of assessments. Knows How had the largest percentage containing 32% of the curriculum assessments. Shows How and Does levels contained an equal number of assessments with each accounting for 24% of the curriculum assessments.

FIGURE 4
FREQUENCIES OF ASSESSMENTS BY MILLER'S PYRAMID LEVEL



AMIA Knowledge Domain

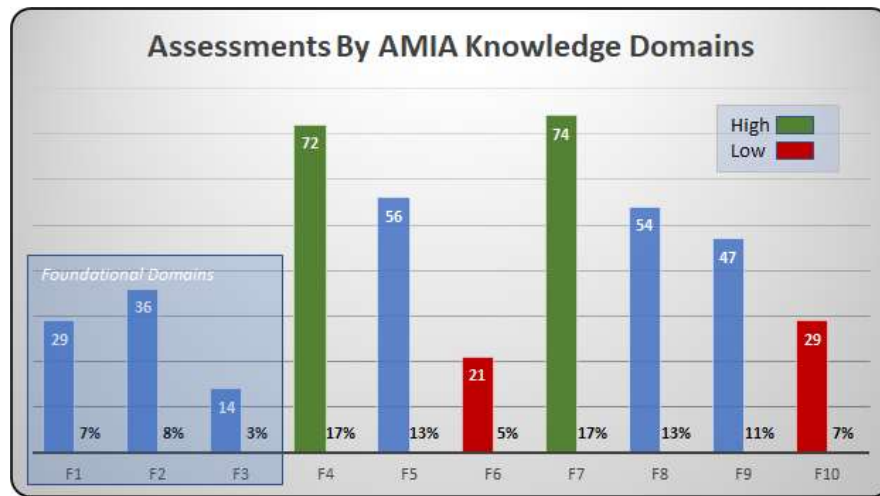
Next, the distribution of assessments across AMIA knowledge domains was analyzed. A breakdown of all assessments by knowledge domains revealed a wide distribution with some domains containing high and low numbers of assessments (Figure 5). F1 Health, F2 Information Science and Technology and F3 Social and Behavioral Science are foundational domains with only knowledge components. Of these, F3 had only 14 or 3% of assessments, making F3, the domain with the fewest assessments. F1 and F2 had more than double the number of assessments at 29 and 36 respectively.

Overall, F4, Health Information Science and Technology and F7, Social, Behavioral and Information Sciences and Technology Applied to Health had the most assessments (72 and 74 respectively) leading them to be the predominant domains in the curriculum. Together, these domains accounted for 34% of the assessments for the core curriculum demonstrating that approximately 1/3 of the curriculum is focused on these two domains.

Beyond these predominant knowledge domains, two other domains addressing full competencies (knowledge, skills, attitudes) had notably low numbers of assessments. F6, Social and Behavioral Aspects of Health and F10, Leadership (21 and 29 respectively). Together, these domains accounted for only 12% of the core curriculum. This finding highlighted the need for further investigation to discover if assessments are reaching the top of the Miller's pyramid or if they are not fully meeting the competencies defined for those domains.

The remaining domains of F5 Human Factors and Socio-Technical Systems, F8 Professionalism, and F9 Interprofessional Collaborative Practice accounted for 37% of the core curriculum with 56, 54, and 47 assessments respectively.

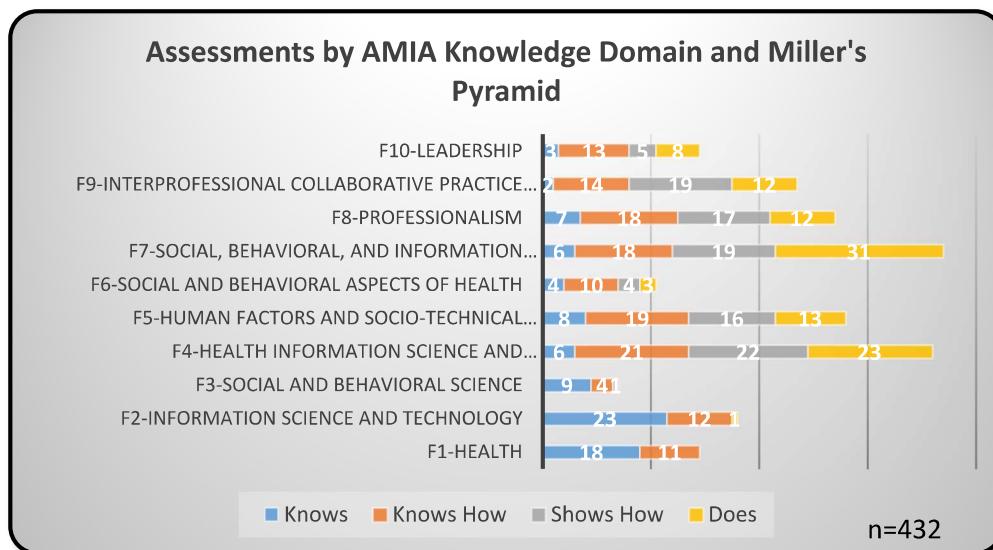
FIGURE 5
FREQUENCIES AND PERCENTAGES OF ASSESSMENTS BY AMIA DOMAIN



To examine both dimensions – Miller’s Pyramid and AMIA knowledge domains simultaneously, frequencies of assessments and distributions are visualized in Figure 6. Overall, 432 assessments are completed in the core curriculum. Our analysis revealed that assessments for F1, F2 and F3 are targeted at the Knows and Knows How levels for Miller’s Pyramid as expected. Additionally, these domains did not contain assessments at the Shows How and Does levels, further confirming that that the assessments for F1, F2 and F3 were appropriately focused.

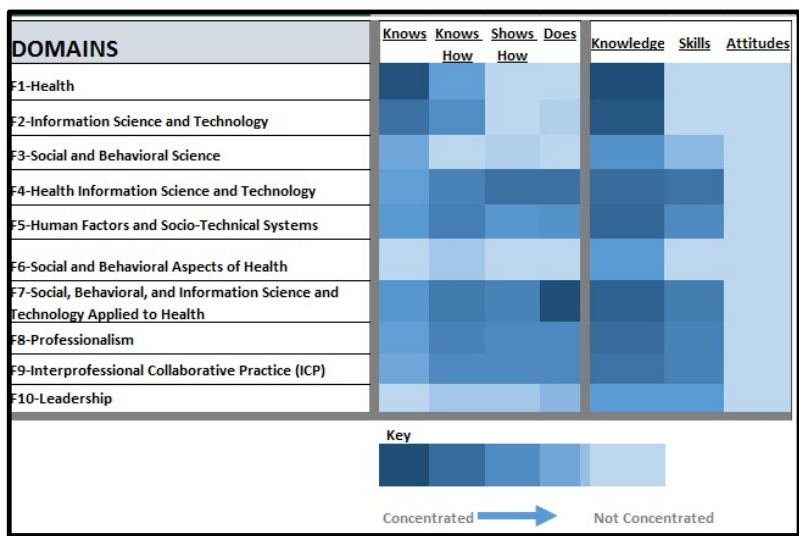
The remaining 7 knowledge domains have knowledge, skills and attitude components. Assessments were distributed across the four Miller’s Pyramid levels with F6 and F10 having the lowest number of assessments and the lowest number of assessments at the Does level of Miller’s Pyramid.

FIGURE 6
DISTRIBUTION OF ASSESSMENTS



Finally, data was entered into the CSET heatmap tool provided by CAHIIM (Figure 7). This visualization of the curriculum displayed areas where assessments were concentrated versus not concentrated. To meet competencies in the domain, assessments must reach the Does level. The heatmap confirmed that F1, F2 and F3 were concentrated at the Knows level. Furthermore, assessments for F6 and F10 were not concentrated at the Does level. The remaining domains did show that domains became more concentrated at the Shows How and Does levels. The most highly concentrated domain was F7 which is where all domains in the AMIA Venn diagram framework overlap (Valenta, 2018). Again, F6 and F10 were at an overall lower level of concentration, indicating a need for remediation to ensure that competencies are met.

**FIGURE 7
CORE CURRICULUM HEATMAP**



DISCUSSION

For more than a decade, the HI field has made great progress in defining HI competencies for the rapidly evolving field of biomedical and health informatics (J Mantas et al, 2010; Kampov-Polevoi, 2011; CHIA, 2013; AMIA, 2017; Sapci, 2020). AMIA and CAHIIM recognized that programs are unique in their emphasis and that competencies must be defined by each program to reflect the unique curricular identity. Examining the AMIA knowledge domains reveals the identity or major emphasis of an HI program based on what faculty have chosen to teach and assess. For UIC, F4, Health Information Science and Technology and F7, Social, Behavioral and Information Sciences and Technology Applied to Health were the predominant domains in the curriculum accounting for 34% of the assessments for the core curriculum and thus, could be viewed as the curricular identity for the UIC program if changes are not made. While programs may intend to have a particular focus, the curriculum mapping exercise can reveal that - what you thought you were, may not be what you actually are according to the data.

The fact that F3 had half the number of assessments compared to the other foundational domains raises the question - are more assessments needed in this domain? Similarly, F6 and F10 had notably lower numbers of assessments also making them less concentrated than the highest domains, but how much higher do they need to be to be acceptable? Figure 7 shows the attitudes column as not concentrated. It is important to note that this first version of the CSET tool did not include attitudes, the third component of competencies. CAHIIM has now published a second version of the CSET and heatmap tool which includes assessment of attitudes giving programs a complete picture of the competencies. Our approach was to

address these lowest domains because they were low/not concentrated, and also because the faculty viewed these areas as being critical to the curricular identity of the UIC program. Currently, there are no minimum or recommended thresholds defined for domains. This means that, for now, programs must decide what is needed for their program and develop a rationale to support their decisions.

HI curricula have already begun to shift from offering a content-based curriculum focused on knowledge (Huang, 2007; Sapci, 2020). Recent years have also brought an increasing scrutiny of the value of higher education from students who are voicing dissatisfaction with high tuition and questioning whether their education actually will prepare them to work in their chosen field (Cohen, 2015). To provide value, HI programs must embrace their role in educating a workforce that is prepared for new roles requiring competence that includes knowledge, specific hands-on skills and professional attitudes. Knowing and knowing how do not fully meet the needs of the labor market and therefore do not provide enough value. Examples of growing areas in HI that need a well-prepared and skilled workforce include data analytics, consumer and mobile health and translational bioinformatics.

Beyond the goal of meeting accreditation requirements, the competency project was an opportunity to inject quality through a rigorous evaluation of a ten-year-old curriculum. The HI field continues to mature and both higher education programs and employers of health informaticists have developed a more specific ideas on what competencies are needed. An important finding is that the program has been doing a good job of covering these competencies already. As demonstrated by both Figures 6 and 7, many of the domains were being met without needing revisions. However, it is incumbent upon higher education to continue to examine our processes and products to ensure we are doing the job our customers need (Christensen, 2011).

Because HI programs are just beginning the process of becoming competency-driven, there are many unknowns as programs make their way through the process. For UIC faculty, numerous questions arose such as what the levels in the heatmap actually represented, and how much concentration is enough both to meet CAHIIM requirements and to fully meet the defined competencies. Faculty discussed if the Miller's Pyramid levels should be balanced across the curriculum and whether a medium coverage of an AMIA domain was sufficient.

Future research is needed to delve into analytics for competencies and publish recommended guidelines that address these questions. More work is needed to understand measurements related to competencies across a curriculum such as how much concentration is sufficient for meeting a knowledge domain or how assessments should be balanced across the domains. For example, in the UIC curriculum, 20% of assessments were at the Knows level of the Miller's Pyramid. This appears to support the idea that competence builds as students' progress through the program since the other 80% of assessments were higher on the Miller's Pyramid.

A New Paradigm for Health Informatics Education

Moving to a new approach such as competency-driven curriculum is paradigm shift for programs and a major change management project requiring attention to address barriers (Palumbo, 2019). Project leaders spent significant time developing communications, a well-constructed process and tools to manage ambiguity and build faculty competence in designing this new curriculum. Beyond the work to redesign courses, a good amount of effort is required to build readiness to accept the changes that a competency-driven curriculum will bring. Change management must address stakeholder concerns, communication, education and must emphasize the benefits to the new approach. Change management cannot be rushed. The entire competency project will take two years to complete and it could not have been done any more quickly. There is work involved in the basics of understanding the new paradigm, working through the iterative process and discovering where there are gaps and where the program is already doing a good job, and becoming comfortable with a new approach to achieving learning outcomes.

To be successful in a project such as this requires faculty to work together and share the details of what they do in their courses. Faculty can become protective of their courses and work in silos losing sight of how their courses fit into the overall curriculum. Where they may previously have been operating independently, this project required collaboration and negotiation to establish pathways of interdependence and scaffolding throughout the curriculum.

Courses must contribute to meeting the competencies. In some cases, the data revealed that assessments were not contributing to meeting a competency. This may not be a surprising finding for a long-established program where newly defined competencies are essentially being retrofitted to an existing curriculum. However, it also raises the question, “If it does not meet a competency, then why are we teaching this?”. While the UIC curriculum was meeting the majority of the domains, it was not meeting all of them to the desired level. Individual efforts had been made to improve courses to deliver some needed HI skills, but when assessments were compared to the definitions in the AMIA domains, the Miller’s Pyramid of competence and the UIC defined competencies, gaps were revealed. The *Health Informatics Assessment and Scaffolding Tool* was invaluable for facilitating collaboration among small groups of faculty. Gaps were evident to everyone in the group resulting in negotiations and solutions. The tool can be adapted to any set of defined competencies and thus can be used by any HI program engaged in developing a competency-driven curriculum.

As faculty worked toward the new paradigm, it was necessary to accept some level of ambiguity as new steps in the process were started. Then, as the faculty themselves developed competence in designing a new curriculum, they gained clarity and applied new knowledge to the next iteration of building the new curriculum. We, the faculty, also went beyond knowing and into doing (ex: workshop activities, sub-workgroup scaffolding).

Embracing the role of being a talent provider in the Chicago labor market also required project leaders to establish the benefit of doing the project beyond compliance with accreditation. Development of communications, tools and resources conveying the importance of establishing a strong link between students receiving education and their eventual goal of building a successful health informatics career builds quality into the health informatics program.

Recommendations for Practice and Future Research

The experience of doing this project led to the following recommendations that may benefit others working on a similar initiative:

- This is a major **organizational change** effort focused on the curriculum, and it involves a paradigm shift for faculty.
- It is easy to lose focus, develop a **project timeline** and manage to it.
- Provide **multiple opportunities** for faculty discussions to build readiness to make these changes.
- Form a committee and workgroups and **define activities** they need to complete. Structure meetings to complete these tasks.
- This type of initiative **cannot be rushed**, the UIC project will take 2 years.
- All work and decisions for the project should be data driven.
- Don’t expect all of the faculty to become experts at designing a competency-driven curriculum. **Develop tools** that incorporate the concepts and facilitate the process by walking faculty through the steps to analyze their courses.

This paper describes the UIC process for converting to a competency-driven curriculum and how the effort resulted in meeting AMIA knowledge domains, Miller’s Pyramid levels and defined competencies. Future research might consider how other institutions approached the shift to competency-driven curricula which could lead to a better understand of optimal concentration levels for all of the categories and publication of guidelines. Beyond describing the frequencies and distributions, research should explore how these competencies are linked to learning outcomes and graduates successfully finding HI jobs.

ACKNOWLEDGEMENT

The author would like to acknowledge Clinical Associate Professor Eric Swirsky, University of Illinois at Chicago for his intellectual contribution providing insight and perspective into descriptions of the process faculty used during this project and included in this manuscript.

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