Implementing Competency-Based Education
A Process Workbook
2009–2011

Terri C. Dilmore, PhD, Program Co-Director
Debra W. Moore, PhD Candidate, Graduate Student Researcher
Zuleikha J. Bjork, BFA, Research Education Coordinator

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Steven E. Reis, MD, Principal Investigator
Associate Vice Chancellor for Clinical Research, University of Pittsburgh

Wishwa N. Kapoor, MD, MPH, Program Co-Director
Co-Director, Clinical and Translational Science Institute, University of Pittsburgh

Suzanne Lane, PhD, Consultant
Professor, Department of Psychology in Education, University of Pittsburgh

Carol Washburn, PhD, Consultant
Senior Instructional Designer, Center for Instructional Development and Distance Education, University of Pittsburgh

Competency-Based Education Internal Advisory Committee
Implementing Competency-Based Education
Process Workbook, Supplement Funded by NCRR 2009–2011

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   • Organized a Faculty Seminar on Teaching Methods
   • Preparing CBE Process Paper for Publication in CTS Journal
   • Published Paper on Developing a PhD Program in CTS Journal
   • Preparing Paper on Assessment in CBE for Publication in CTS Journal

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Introduction

Background
The University of Pittsburgh was awarded a Clinical and Translational Science Award (CTSA) in 2006. The CTSA provided funding for the creation of the University of Pittsburgh’s Clinical and Translational Science Institute (CTSI) founded for the purpose of training health sciences professionals to be clinical and translational researchers. The Institute offers one certificate and two degree-granting programs:

The Certificate in Clinical Research Program is for any level of trainee who wants to learn to design and conduct clinical research involving human subjects.

The Master of Science (MS) in Clinical Research Program is for medical students, fellows, and faculty members who want training in the design and implementation of clinical research involving human subjects.

The specialty tracks, distinguished primarily along methodological grounds, allow trainees to concentrate on the type of research in which they plan to participate during their career.

The Clinical Trials Research Track provides training in the design, conduct, and analysis of experimental studies (phase 1, 2, and 3 trials) through didactic and practical experiences.

The Health Services Research Track provides training in analytic methods, outcomes measurement, and cost-effectiveness analysis.

The Health and Behavior Research Track trains those interested in behavioral health research and is conducted jointly with the Department of Psychiatry.

The Translational Research Track trains investigators to implement translational research projects in the clinical setting.

The PhD in Clinical and Translational Science Program is for researchers who want advanced training in conducting independent research in CTS.

Competency-based Education (CBE)
In 2009, the University of Pittsburgh’s Education Core was awarded a 2-year supplement to develop and implement a Competency-Based Education (CBE) curricular framework for the Institute for Clinical Research Education’s (ICRE) certificate and degree-granting programs. The goals of this supplement were to enhance and improve the curricular structure and to collect and organize methods in teaching and assessment within a CBE framework.

Competencies specifically outline what is expected of learners and what learners should be able to attain upon completion of the program of study. Emphasis is placed on performance (not just knowledge) and the demonstration of learning. Within this structure, the learners and the program will be assessed on the basis of competencies related to the content and skills reflective of the field of Clinical and Translational Science (CTS).

This workbook is a comprehensive collection of project documents organized chronologically.
Process

Step 1: Conducted a Literature Review
A comprehensive literature review was conducted across several domains. The team began by reviewing a variety of standard databases, bibliographies, and university Web sites to collect peer-reviewed articles, reports, books, and other information pertinent to CBE, teaching, assessment, developing expertise, and course requirements for research-based degree programs.

Understanding the history of CBE and how CBE was conceptualized in disciplines already using this educational philosophy was fundamental to the project. Several disciplines have a history of using CBE; medicine, dentistry, pharmacy psychology, engineering and education. Knowing how CBE was implemented in these disciplines helped the team develop a similar, but appropriate, structure within CTS. Lessons learned from the implementation of CBE in other disciplines helped to identify obstacles and inform decision-making rather than starting from “scratch”.

To develop the theoretical and program specific curricular models, it was necessary to know the course requirements for other CTSIs as well as the course requirements for other research-based programs across the United States. University Web sites and graduate school bulletins were consulted for course requirements for related disciplines as well as those for other CTSIs. This process not only helped to develop the competencies that inform the CTS curriculum, but also served as standard of comparison during the program evaluation phase of the project.

In addition to the competencies for the core curriculum at the master’s level, the team was asked to help develop doctoral competencies. This necessitated a review of the literature concerning the nature of doctoral programs, the structure of doctoral programs, and a program comparison of research-based doctoral degree programs across the United States.

Instruction and assessment within CBE are specific to the development and evaluation of the integration of knowledge, skills, and attitudes (competence) which define the discipline. Competence is developmental and a step towards developing expertise, so the development of expertise was an important topic for review. Teaching for expertise/competence requires specific teaching methods that use teaching techniques which foster the integration of knowledge, skills, and attitudes. Likewise, assessment of expertise/competence requires assessment methods that allow the learner to integrate the knowledge and skills in a meaningful way.

In addition, designing a college-level curriculum to develop competence in any discipline requires an understanding of the special needs of adult learners. Therefore, an understanding of adult learning theory was necessary to ensure that professional development materials on instruction and assessment created for the faculty were aligned with adult learning’s basic principles.

These literature reviews served as the basis for developing conceptual and specific models for the project and for preparing curricular support materials for faculty and staff during implementation.
Process

**Step 2: Developed a Theoretical Competency Framework**

The team designed theoretical models to guide the development of the competency-based educational program. The Theoretical Program Planning Model (Figure 1) delineates the steps involved in developing and implementing an outcomes-based educational program. It describes each step, shows how the steps are related to the overall educational structure, and illustrates the iterative nature of curriculum development.

The Theoretical Competency Framework (Figure 2) summarizes the process of operationalizing competencies. While competencies establish expectations about what learners should be able to do, objectives provide operational definitions outlining how competence will be measured and performance levels set the standard at which competence should be demonstrated.
Process

Step 3: Developed a Program-Specific Model
The Theoretical Competency Framework was further elaborated into a Program-Specific Model (Figure 3) that details the competency structure specific to clinical and translational science (CTS).

The certificate, MS, and PhD programs share competency clusters of foundational skills and functional skills. **Foundational skills** encompass the basic knowledge needed within the discipline. **Functional skills** are the skills needed for researchers to function as professionals within the field of CTS. Both of these competency clusters are broken down into competency domains.

**Competency domains** specify fundamental aspects within the discipline. The competency domains that define foundational skills are research design and data analysis. The competency domains that define functional skills are professional skills and teamwork and leadership. Each competency domain is further defined by a set of specific competencies.

The **specific competencies** describe the knowledge, skills, and attitudes expected of learners in CTS. It is within the specific competencies that levels of mastery are defined, with the certificate, MS, and PhD requiring progressively greater levels of mastery in the learning and behavioral objectives associated with each competency.

**Superordinate competencies** of ethics and cultural sensitivity permeate the whole educational structure and are interwoven throughout the competencies at all levels of mastery.

Figure 3: Program-Specific Model, MS
Process

**Step 3: Developed a Program-Specific Model**, continued

While competency clusters and domains across degree programs are identical, specific competencies are not. In addition, there is an increased level of mastery, as defined by the learning and behavioral objectives, associated with common specific competencies.

Within the program structure already established at the ICRE, the certificate would represent the most basic level of mastery within the CBE structure. The other degree programs would build on the basic level of competence required of certificate level learners.

The **MS** would be differentiated from the certificate by the addition of competencies focused on management and the inclusion of objectives specific to grant writing. The master’s level learning and behavioral objectives would require a higher level of mastery above and beyond that expected of certificate level learners. All four specialty tracks have the same competency domains and specific competencies but each is defined by objectives unique to each track’s focus.

Likewise, in addition to learning and behavioral objectives that would require a higher level of mastery above and beyond that of a master’s level learner, the **PhD** is differentiated from the MS and the certificate by the addition of competencies focused on leadership and teaching (Figure 4).
Process

**Step 4: Developed Curricular Frameworks**

The curricular frameworks were structured from general to specific beginning with broad competency clusters of foundational skills and functional skills and becoming specific in the form of learning objectives and behavioral objectives which operationalize the competencies. **Learning objectives** are broad statements representing the integration of knowledge and skills. Learning objectives may or may not be specific enough to measure directly; therefore, most were further operationalized with behavioral objectives. **Behavioral objectives** specify how competencies will be measured within the curriculum. Individual curricular frameworks were created for the certificate, MS (Figure 5), PhD, and MS specialty tracks. These specialty tracks include: Clinical Trials Research; Health Services Research; Health and Behavior Research; and Translational Research.

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**Core Competency Requirements for the Master’s of Science (MS) in Clinical Research at the University of Pittsburgh**

<table>
<thead>
<tr>
<th>I. Competency Cluster: FOUNDATIONAL SKILLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Competency Domain: Research Design</td>
</tr>
<tr>
<td>A. Specific Competency: Problem Formulation</td>
</tr>
<tr>
<td>1) Learners will propose significant and novel empirical research questions.</td>
</tr>
<tr>
<td>• Learners will evaluate the importance of biomedical, clinical or public health research problems.</td>
</tr>
<tr>
<td>• Learners will determine when to formulate translational research questions based on the identification of biomedical, clinical or public health problems cited within the literature.</td>
</tr>
<tr>
<td>• Learners will recognize when to incorporate different disciplines into investigative approaches to a research topic.</td>
</tr>
<tr>
<td>• Learners will develop testable hypothesis-driven research questions.</td>
</tr>
<tr>
<td>• Learners will identify community engagement as a strategy in testable research questions.</td>
</tr>
<tr>
<td>2) Learners will use evidence to critically review published studies that use varying research methodologies.</td>
</tr>
</tbody>
</table>

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**Figure 5**: A portion of the MS Framework

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Process

Step 5: Combined University of Pittsburgh and National Center for Research Resources Competency Documents

After completing the curricular frameworks, it was necessary to align them with the “Core Competencies in Clinical and Translational Research” created by the National Center for Research Resources (NCRR). This document represents the current national expectations for degree-granting programs in CTS. A comprehensive comparison of the NCRR document and curricular frameworks developed in this project was performed. The four competency domains outlined by the program-specific model for the University of Pittsburgh were compared to the NCRR document. Consensus among faculty and project team was established concerning overlaps between the specifics of each document. The figure below (Figure 6) shows how each NCRR Competency Theme is included in one or more of the four University of Pittsburgh Competency Domains.

![Diagram of Pitt Competency Domains and CTSA/NCRR Competency Themes](image-url)

**Figure 6:** Relationship between University of Pittsburgh and NCRR competency documents
Process

**Step 6: Reviewed Curricular Materials and Aligned Curricular Frameworks with Core Courses**

After developing the curricular frameworks, they were then mapped to the core courses at the master’s level. First, a matrix of core courses by competency structure was created. Next, a list of current and potential teaching and assessment methods, supportive of CBE was compiled based on review of the syllabi and the literature review conducted at the beginning of the project. Finally, all syllabi, course materials, assignments, and assessments were collected and reviewed. Through analysis of these materials, it was determined to what extent (full or partial) each learning and behavioral objective was being covered, assessed, and graded in each of the six core courses. In addition, the way in which the content was covered (teaching method) and the ways learners were being evaluated (assessment methods) were also noted (Figure 7).

<table>
<thead>
<tr>
<th>KEY: Codes for Alignment</th>
<th>Teaching Methods</th>
<th>Assessment Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage</td>
<td>CB Computer-based modules</td>
<td>HW Homework</td>
</tr>
<tr>
<td></td>
<td>CS Case studies</td>
<td>IO In-class, oral</td>
</tr>
<tr>
<td></td>
<td>GP Guided practice</td>
<td>IW In-class, written</td>
</tr>
<tr>
<td></td>
<td>LB Lab</td>
<td>PA Peer assessment</td>
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<tr>
<td></td>
<td>LE Lecture</td>
<td>PP Paper/proposal</td>
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<tr>
<td></td>
<td>SG Small group</td>
<td>QU Quiz</td>
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<td></td>
<td>SI Simulation</td>
<td>SA Self assessment</td>
</tr>
<tr>
<td></td>
<td>SP Student presentation</td>
<td>TE Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CORE COURSES</th>
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<tbody>
<tr>
<td>CLRES 2005: Computer Methods for CR</td>
</tr>
<tr>
<td>CLRES 2010: CR Methods</td>
</tr>
<tr>
<td>CLRES 2020: Biostatistics</td>
</tr>
<tr>
<td>CLRES 2040: Measurement in CR</td>
</tr>
<tr>
<td>CLRES 2050: Ethics and Regulation</td>
</tr>
<tr>
<td>CLRES 2071/2072: Research Design and Dow. Seminar 1 &amp; 2</td>
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</tbody>
</table>

**I. Competency Cluster: FOUNDATIONAL SKILLS**

**1. Competency Domain: Research Design**

**A. Specific Competency: Problem Formulation**

1) Students will propose significant and novel empirical research questions.

- Students will evaluate the importance of biomedical, clinical or public health research problems.

Figure 7: Section of MS Framework to Core Course Alignment
Process

Step 7: Reviewed Core Course Alignments with Course Faculty

Upon completion, the alignment documents were discussed with each core course instructor. The degree of agreement between what the project team determined to be the level of coverage and assessment of every learning and behavioral objective in each course with what the course instructor felt to be the level of coverage and assessment was calculated (Figure 8). The percent agreement was determined by counting the number of times the course instructor and the project’s reviewers strictly agreed concerning content coverage and dividing by the number of agreements possible for each competency. The same procedure was used to determine percent agreement for assessment.

This procedure was important so instructors could see how the project team viewed course elements and to give the project team a sense of how instructors perceived their course elements. In addition, high agreement would allow the project team to continue aligning courses for the specialty tracks with confidence.

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### Percent Agreement between Project Team and Core Course Instructor by Specific Competency

<table>
<thead>
<tr>
<th>CORE COURSES</th>
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<tbody>
<tr>
<td>1. Specific Competency</td>
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<tr>
<td>A. Subordinate Competency</td>
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<table>
<thead>
<tr>
<th>I. FOUNDATIONAL SKILLS</th>
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<tbody>
<tr>
<td>1. Research Design</td>
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<tr>
<td>A. Problem Formulation</td>
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<tr>
<td>B. Methodology</td>
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<tr>
<td>C. Sampling</td>
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<tr>
<td>D. Measurement</td>
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<table>
<thead>
<tr>
<th>2. Data Analysis</th>
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<tbody>
<tr>
<td>A. Data Management and Biomedical Informatics</td>
</tr>
<tr>
<td>B. Applied Analytic Techniques</td>
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<table>
<thead>
<tr>
<th>II. FUNCTIONAL SKILLS</th>
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<tbody>
<tr>
<td>1. Professional Skills</td>
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<tr>
<td>A. Oral Communication</td>
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<tr>
<td>B. Written Communication</td>
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<tr>
<td>C. Ethics and Professional Norms</td>
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<table>
<thead>
<tr>
<th>2. Management and Leadership</th>
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<tbody>
<tr>
<td>A. Multidisciplinary Teamwork</td>
</tr>
<tr>
<td>B. Management</td>
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</tbody>
</table>

*Figure 8: Percent agreement document*
Process

**Step 8: Identified Curricular Gaps and Made Recommendations**

Using the alignment documents, gaps in coverage and assessment across the MS curriculum were identified. Recommendations concerning the type and degree of coverage and assessment that would be needed to address the gaps for each course were summarized in a report shared and discussed with each course instructor (Figure 9).

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**Gaps and Recommendations Summary**

**CLRES 2071/2072 Research Design and Development Seminar (Grant Writing)**

In general, most learning objectives are covered across the core curriculum in the appropriate courses. However, there is a lack of sufficient practice of skills covered in the learning objectives and a lack of sufficient assessment for several learning objectives. In all courses, there is a need to identify specific places within the core curriculum where learners can be instructed in the functional skills (written communication, oral communication, ethics and professional norms, multidisciplinary teamwork, and management), and be given opportunities to practice the skills and be assessed on the development of these skills.

There are several issues with the Research Design and Development course which need to be addressed and/or acknowledged:

1. There is a lack of assessment throughout the course.
   - a. There is no standardized assessment instrument that can be used across the groups to ‘grade’ the final grant product.
   - b. There is no documentation of the work that is done in the small groups.
   - c. There is no documentation of the drafts and revisions of the grant.
   - d. There is no assessment of the individual parts of the final grant product.

2. There is no consistent experience in the course due to the nature of the small group experience and the fact that each student is writing a grant that is in their area of interest. Therefore, the only objectives that the course truly covers are those topics covered in the large group sessions. These objectives are not being assessed.

3. Since this course is treated as a capstone course, there should be sufficient practice of the skills required of the students to successfully complete this course in previous courses. This should not be the first time students are exposed to and asked to do these skills.

4. Since the course focuses on aspects of the competencies only in the context of one research problem, generalizations about a student’s competence based solely on this course are not reasonable. There is too much of the assessment of competence burden put on this course.

5. Even though the small groups are unique, problems and issues that arise in individual groups should be disseminated to the larger group for instructional purposes.

This course would better serve its purpose if it was later in the educational sequence. At that point, students would be more likely to have the requisite skills and knowledge in their
Process

Step 9: Reviewed Curricular Materials and Aligned Track-specific Frameworks with Core and Track Courses

After completing the MS core course curriculum alignment, the team began an alignment of the track-specific courses. Since there are required and recommended courses, as well as electives, for each track, it was necessary to determine which courses were being taken as required, recommended, or outside of track (Figure 10). This gave the team a sense of how the courses were functioning within the curriculum. This information can be used by program directors to revise course requirements.

![Figure 10: Cross-course schematic](image-url)

### Enrollment in Required, Recommended, and Out-of-Track Courses by Year

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<td><strong>7 7 5 5 3 0 3 3 1 1 1 0 4 1 0</strong></td>
<td><strong>6 6 3 3 3 0 0 3 2 1 0 0 2 0 0</strong></td>
<td><strong>28 29 24 22 5 0 11 9 3 2 1 11 1 0</strong></td>
<td><strong>1 1 0 0 0 1 2 1 1 1 0 1 0 3</strong></td>
<td><strong>2 2 2 0 0 0 3 4 1 0 5 0 1 0 3</strong></td>
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<td><strong>1 1 0 0 0 1 1 1 0 1 0 3</strong></td>
<td><strong>4 4 2 0 0 5 14 7 4 9 1 5 0 17</strong></td>
<td><strong>52 51 40 38 20 43 26 16 7 11 2 16 1 17</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total took</strong></td>
<td><strong>52 51 40 38 20 43 26 16 7 11 2 16 1 17</strong></td>
<td><strong>91% 82% 64% 73% 68% 69%</strong></td>
<td><strong>64% 66% 55% 50% 11%</strong></td>
<td><strong>50% 50% 25%</strong></td>
<td><strong>63% 27% 13% 6% 17% 2% 12% 1% 23%</strong></td>
<td><strong>55% 55% 41% 14% 9% 5% 33%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
<td><strong>41% 41% 34% 22% 9% 15% 3% 22% 1% 23%</strong></td>
</tr>
</tbody>
</table>

Percent take req = percent of students for which the course is required that took it
Percent take suggest = percent of students for which this was a suggested elective, but not required, that took it
Percent take out of track = percent of students for which this was not required or suggested that took it
Percent take elect = percent of students who took this course as an elective (whether suggested or not)
Green highlight indicates it is a suggested elective for a track
Blue highlight indicates it is a required course for a track
Process

**Step 9: Reviewed Curricular Materials and Aligned Track-specific Frameworks with Core and Track Courses**, continued

Curricular frameworks were mapped to the track core and elective courses in the same manner as described in Step 6 (Figure 11).

### B. Subordinate Competency: Applied Analytic Techniques

1) Students will create appropriate data analysis plans for addressing specific research questions.

   - Students will use a statistical software package to analyze data.
   - Students will use computer software to analyze data.
   - Students will explain the steps involved in organizing, screening and analyzing a given dataset.

2) Students will determine the appropriate statistical technique for answering given research problems.

- Students will interpret computer output containing the results of statistical procedures and graphics.

*Figure 11: Section of MS Framework to Health Services Research Track and Core Course Alignment*
Process

**Step 10: Established Standards of Comparison**

A comprehensive program comparison of the 46 Clinical and Translational Science Institutes (CTSIs) across the United States was conducted. Program requirements for degree and/or certificate programs; including required courses, electives, course descriptions and evaluation methods, were collected for each CTSI (Figure 12).

This comparison was done to determine differences and similarities between the University of Pittsburgh’s program and the programs of its peers. Information about course requirements and milestones gave the team insight into whether curricular expectations were consistent with other CTSIs.

<table>
<thead>
<tr>
<th>University of Pittsburgh CTSI</th>
<th>Region: NE</th>
<th>Year grant awarded: 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MS Required Hours:</strong> 39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MS Graduation Requirements: Thesis</td>
<td></td>
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</tr>
<tr>
<td>MS Web site(s): <a href="http://www.icre.pitt.edu/degrees/ms_cr.html">www.icre.pitt.edu/degrees/ms_cr.html</a></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Required Courses**
- Core Courses (15 credits)
  - Computer Methods in Clinical Research
  - Clinical Research Methods
  - Biostatistics: Statistical Approaches in Clinical Research
  - Measurement in Clinical Research
  - Ethics and Regulation of Clinical Research
  - Research Design and Development 1 and 2

**Electives Credit Requirements by Track**
- Effectives, Outcomes, & Quality Research: 24-26 elective credits
- Clinical Trials Research: 40-42 elective credits
- Health & Behavior Research: 41 elective credits
- Translational Research: 103 elective credits

**Master’s Thesis** (for all tracks): 3 credits

**Optional Content Specialization:** 6 credits

<table>
<thead>
<tr>
<th>PhD Required Hours: 72</th>
<th></th>
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<tbody>
<tr>
<td>PhD Graduation Requirements: Dissertation</td>
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</tr>
<tr>
<td>PhD Web site(s): <a href="http://www.icre.pitt.edu/phd/index.html">www.icre.pitt.edu/phd/index.html</a></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Required Courses**
- Analytic Methods (5 credits)
  - Computer Methods in Clinical Research
  - Biostatistics: Statistical Approaches in Clinical Research
  - Measurement in Clinical Research

- Clinical Research Methods (8 credits)
  - Research Design and Development 1 and 2
  - Clinical Research Methods

**Multidisciplinary Methods (5 credits)**
- Ethics and Regulation of Clinical Research
- Laboratory Methods
- Translational Research

**Advanced Selectives** (10 credits – 6 must be Analytic Methods and 4 must be Clinical Research Methods)

**Research Specialization** (24 credits of research or coursework)

**Dissertation** (10 credits)

*Figure 12: Section of the program comparison document*
Process

**Step 11: Compiled Teaching Methods**

To support faculty as they transition to a CBE curricular structure, a teaching methods toolbox was created (Figure 14). In the toolbox are brief information sheets (Figure 13) describing various selected teaching methods, as well as their strengths and limitations. In addition to supporting a CBE curricular structure, teaching methods chosen were those that:

- model the types of cognitive processes expected of the learner outlined by the curriculum frameworks;
- are interactive and engaging;
- require students to participate in self-directed learning;
- provide opportunities for practice;
- model the integration of knowledge skills, and attitudes;
- accommodate learners with different learning styles.

---

**Teaching Techniques**

**Guided Practice**

**Purpose**

Learning is more valuable when learners are given opportunities to apply and practice what they know, with the direction of the instructor. This encourages more active learning on the part of the learner. Practice “speeds up learning, aids long-term retention, and facilitates recall” (Seels & Glasgow, 1998, 293).

**Goal**

There are three important principles of guided practice, which include (Seels & Glasgow, 1998, 293):

1. Opportunities for practice must encourage learners to actively participate and perform the activity.
2. Practice should occur immediately following the presentation of new content—as it provides an opportunity for learners to practice and apply knowledge that is fresh in their minds.
3. Opportunities for practice must occur regularly so that the student learns how to apply and further understand the content.

**Strengths**

Working actively with the content/material during practice gives learners the opportunity to produce fluency and transfer use. Allowing learners to practice actively, helps them to “recall and use information effortlessly so that they can exert their mental energies not on recall, but on...

---

**General Overview**

- Adult Learning Theory
- Motivating Learners

**Learning Approaches**

- Problem-based Learning

**Teaching Methods**

- Case Studies
- Labs
- Lecture
- Simulation (e.g. Role Playing)
- Small Groups

**Teaching Techniques**

- Brainstorming
- Discussion
- Guided Practice
- Metacognitive Activities
  - Metacognitive Actives: Blank KWL Table
- Questioning
- Reinforcement

**Developing Course Syllabi**

- Developing Course Syllabi
- Fields for Syllabi

**Professional Teaching Development**

- Peer Assessment of Teaching

**Technology in Education/Teaching**

- Blogs
- Discussion Boards
- Wikis
- Chat
- Interactive Whiteboards
- Screen Capture
- Student Response Systems

---

**Figure 13**: A portion of the information sheet on the teaching technique of guided practice

**Figure 14**: Teaching Toolbox outline
Process

Step 12: Compiled Assessment Methods

The Role of Assessment in CBE

In addition to the teaching methods toolbox, an assessment methods toolbox was also created (Figure 15). Assessment plays a very specific role in CBE that is inextricably linked to the instructional methods used. Because of the nature of assessment in CBE, assessments methods that allow for the integration of knowledge, skills, and attitudes, and mimic problems encountered in everyday situations were given priority.

One of the defining characteristics of CBE is frequent formative assessment of knowledge, skills, and attitudes during the development of expertise/competence. Formative assessment occurs while content is being taught and even though it is scored, it is not graded. Formative assessment is designed to give learners constant feedback about their performance and progress in a nonthreatening way. It gives learners substantial opportunities to practice the skills, learn the knowledge, and self-reflect about their learning before they are put in a high stakes situation (pass or fail).

---

General Overview
Introduction to Assessment

Assessment Methods
Creating Performance Assessments
Using Self-Assessment
Using Peer Assessment
Creating Tests/Quizzes/Exams
  Writing Selected-Response Items (Multiple Choice, True-False, Matching)
  Writing Constructed-Response Items (Short Answer, Essay)
Creating Scoring Instruments

Resources
Table of Specifications Template

Ready-to-use Rubrics
Do you need to modify one of these rubrics? If so, see the list of modifiable rubrics below.

Written Communications
Oral Communication
Peer Evaluation
Miscellaneous
Written Assignments
Lab work
Small Group Work
Class Participation

Modifiable Rubrics
Is the rubric you’d like to modify not listed below? If so, please contact bjorkz@upmc.edu to request a modifiable version.

Written Assignments
Miscellaneous
Lab work
Self-Assessment Surveys

Figure 15: Assessment Toolbox outline
Process

**Step 12: Compiled Assessment Methods, continued**

The assessment toolbox features educational modules on general aspects of assessment and specific assessment methods; tests, performance assessments, self-assessment, etc. (Figure 16). Ready-to-use rubrics for different types of assignments were also included in the assessment toolbox to “jump start” implementation by providing faculty with scoring rubrics for activities commonly used in the core courses (Figure 17). As the faculty become more proficient in using scoring rubrics or if they were using an assignment that does not have a scoring rubric created for it, it is possible that they would need to create scoring rubrics of their own. For this reason, Word document versions of some scoring rubrics were included in the assessment toolbox to offer faculty a modifiable template for creating their own rubrics.

**Characteristics of Multiple Choice Items**

Multiple choice items require that learners recognize, not supply, the correct answer. Multiple choice items consist of three parts:

1. the **stem**, which presents a problem situation;
2. the **correct response**;
3. the **distractors**, which should consist of several plausible wrong answers.

The correct response and the distractors are known as **alternatives**.

A distribution of N=10 scores has M=50 and SD = 10. If another five individuals, all with scores of X=50, are added to this distribution, what will happen to the standard deviation?

- **A.** The standard deviation will decrease
- **B.** The standard deviation will increase.
- **C.** The standard deviation will stay the same

**Figure 16:** One slide from the Writing Selected-response Items Module

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate</td>
<td>• Lacks a style and/or format that makes comprehensibility difficult.</td>
</tr>
<tr>
<td></td>
<td>• Fails to cite sources thoroughly and/or completely.</td>
</tr>
<tr>
<td></td>
<td>• Numerous errors in spelling, grammar, and/or sentence structure interfere with comprehensibility.</td>
</tr>
<tr>
<td></td>
<td>• Writing does not flow smoothly; lacks appropriate transitions.</td>
</tr>
<tr>
<td>Developing</td>
<td>• Some analysis is present, but major ideas related to the content are absent or inadequately explored.</td>
</tr>
<tr>
<td>Competence</td>
<td>• Organizational structures are not present or not used effectively.</td>
</tr>
<tr>
<td>Competent</td>
<td>• Analysis of existing scholarly/professional literature on the topic is absent.</td>
</tr>
<tr>
<td></td>
<td>• Summary of related literature is inadequate.</td>
</tr>
<tr>
<td></td>
<td>• Content is poorly focused and scholarly argument is poorly conceived.</td>
</tr>
<tr>
<td></td>
<td>• Reader is left with little new information about or understanding of the topic.</td>
</tr>
<tr>
<td>Advanced</td>
<td>• Models the language and conventions used in related professional literature.</td>
</tr>
<tr>
<td></td>
<td>• Meets the guidelines for a professional publication.</td>
</tr>
<tr>
<td></td>
<td>• Essential error free.</td>
</tr>
<tr>
<td></td>
<td>• Transitions help establish and advance a sound scholarly argument and aid comprehensibility.</td>
</tr>
<tr>
<td></td>
<td>• Skilled use of organizational structures.</td>
</tr>
<tr>
<td></td>
<td>• Is interesting and holds the reader’s attention.</td>
</tr>
<tr>
<td></td>
<td>• Raises important issues or ideas that may not have been represented in the literature cited.</td>
</tr>
<tr>
<td></td>
<td>• Would serve as a good basis for further research on the topic.</td>
</tr>
</tbody>
</table>

**Figure 17:** Written communication holistic scoring rubric

Process

**Step 12: Compiled Assessment Methods**, continued

In the master’s program, learners have a choice between a thesis, a research proposal, or two publishable manuscripts as their milestone. Milestones of this nature should be comprehensive in their evaluation, consistent with the underlying competencies, and evaluated to a standard consistent with the expectations of the program. Therefore, although beyond the aims of this grant, a comprehensive and detailed scoring rubric with clearly defined levels of performance was designed to assist faculty evaluators for the research proposal option (Figure 18).

---

**Institute for Clinical Research Education, MS in Clinical Research Comprehensive Research Project Scoring Rubric**

The objective of this milestone in the MS Program in Clinical Research Science is to provide students with the opportunity to demonstrate depth of knowledge in core methods, study design, analytical techniques and ethics and professional norms within their specialization in clinical and translational science. Through this comprehensive research project, the student is expected to demonstrate sufficient knowledge to be granted their master’s degree. Successful completion of this research project is a requirement for the program.

<table>
<thead>
<tr>
<th>Category</th>
<th>1 Advanced</th>
<th>2 Competent</th>
<th>3 Borderline</th>
<th>4 Developing Competence</th>
<th>5 Inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>Thorough demonstration of knowledge of key concepts relevant to proposed project. Clear ability to provide complete connections between concepts and provide rationales and/or explanations across all components of the proposed project.</td>
<td>Provides consistent but not necessarily thorough demonstration of knowledge of key concepts relevant to proposed project. Ability to make most connections between concepts and provides adequate rationales and/or explanations across all components of the proposed project.</td>
<td>Provides inconsistent demonstration of knowledge of key concepts relevant to proposed project. Inability to make complete connections between concepts. Provides shallow rationales and/or explanations across all components of the proposed project</td>
<td>Lack of ability to sufficiently demonstrate knowledge of concepts relevant to proposed project. Failure to make any logical connections between concepts. Incomplete and/or shallow rationales or explanations across all components of the proposed project</td>
<td>Inability to demonstrate knowledge of concepts relevant to proposed project. Failure to make any logical connections between concepts. Unable to provide rationales or explanations across all components of the proposed project.</td>
</tr>
</tbody>
</table>

**A. Research Methods and Design**

1. Students will conduct a comprehensive literature review to justify the research problem addressed within the proposed project.

---

**Figure 18: MS milestone scoring rubric**

---

Process

**Step 13: Created Project Web Site**

A Web site (Figures 19 and 20), www.icre.pitt.edu/cbe, was created to provide information and resources for implementing a CBE structure at the Institute for Clinical Research Education (ICRE). This Web site serves as the home for curriculum and competency tools and is a resource for course design and implementation. This Web site defines CBE; explains implementation of CBE at the ICRE; and provides faculty with resources including teaching and assessment tools.

![Fig 19: Web site homepage](image)

![Fig 20: Main menu for the faculty resources section of the Web site](image)
Implementation
The implementation phase of the project began in the summer of 2010 by making the project Web site available to all instructors, piloting CBE elements into two core courses, and beginning to collect data to evaluate the effectiveness of a competency-based curriculum in CTS.

Even though only two courses were targeted for implementation, several instructors tried to incorporate elements of CBE into their own courses. In addition, the director of the institute identified a course that needed help and asked the project team to assist as well. The project team served as a resource group for all instructors as they designed exams consistent with best practice, added practice opportunities in the form of new or revised assignments, and used scoring rubrics to standardize the grading of subjective assignments.
Implementation

**Step 1: Piloted Curricular Structure**
Elements of a CBE curriculum were piloted in two courses: CLRES 2040 Measurement in Clinical Research and CLRES 2071/2072 Research Design and Development Seminar during 2010–2011. As part of the piloting process, student self-assessment surveys were administered on the first and last day of each course (Figure 22). In addition, course instructors were provided with materials for CBE implementation including syllabi and scoring rubrics (Figure 21) to support assessment and documentation of competency development.

---

**Assessment of Grant Proposal Peer-review Assignment**

<table>
<thead>
<tr>
<th>Name:</th>
<th>Date of Assignment:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Score</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: Beginner</td>
<td></td>
</tr>
<tr>
<td>• Most or all comments are general and/or vague</td>
<td></td>
</tr>
<tr>
<td>• Points out exclusively negative aspects OR everything is commented as good</td>
<td></td>
</tr>
<tr>
<td>Level 2: Developing</td>
<td></td>
</tr>
<tr>
<td>• Some specific meaningful comments given, but most comments are general and/or vague.</td>
<td></td>
</tr>
<tr>
<td>• An attempt is made to point out positive and negative aspects.</td>
<td></td>
</tr>
<tr>
<td>• Comments are undifferentiated and cannot provide adequate direction for elaboration on concepts</td>
<td></td>
</tr>
<tr>
<td>• All sections of grant proposal may or may not have applicable comments.</td>
<td></td>
</tr>
<tr>
<td>Level 3: Competent</td>
<td></td>
</tr>
<tr>
<td>• Meaningful comments given</td>
<td></td>
</tr>
<tr>
<td>• Points out positive and negative aspects</td>
<td></td>
</tr>
<tr>
<td>• All sections of grant proposal have applicable comments</td>
<td></td>
</tr>
<tr>
<td>Level 4: Advanced</td>
<td></td>
</tr>
<tr>
<td>All characteristics of Level 3: Competent plus:</td>
<td></td>
</tr>
<tr>
<td>• Insightful comments given</td>
<td></td>
</tr>
<tr>
<td>• Comments are sophisticated and would enable grant writer to improve proposal</td>
<td></td>
</tr>
</tbody>
</table>

---

**Self-Assessment Survey**

Measurement Course 2040, Spring 2011

The statements in questions 1 – 10 will help us to better understand your opinions about measurement principles. Please read each statement and mark the one response that most clearly represents your degree of agreement or disagreement with each statement. Please respond to all of the statements.

**My level of training is:**

- [ ] Graduate Student
- [ ] Junior Faculty
- [ ] Resident
- [ ] Senior Faculty
- [ ] Medical Student
- [ ] Other, please specify: 

<table>
<thead>
<tr>
<th>Items</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Measurement plays a fundamental role in the design of research studies.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>2. The principles of measurement are important to understand in order to effectively answer research questions.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>3. I feel competent in applying the principles of measurement to my own research.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4. The study of measurement principles is useful in helping me to become competent as a clinical and translational researcher.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>5. I have a good understanding of measurement principles.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>6. Measurement principles are NOT applicable to my area of research.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7. Understanding measurement principles will help me analyze my research data.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>8. Understanding measurement principles will help me interpret the results of my research data.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>9. Understanding measurement principles improves my ability to critically review published literature.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>10. Understanding measurement principles will improve my ability to develop research proposals.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

---

*Figure 21: Rubric created for use in CLRES 2071/2072 Research Design and Development Seminar*

*Figure 22: Sample student self-assessment instrument*
Implementation

Step 2: Evaluated Effects of Implementing a Competency-Based Educational Curriculum in Piloted Courses

A longitudinal study, to determine the effects of applying a CBE curriculum within the ICRE, was undertaken. Part of this process included collecting materials and results of student evaluations from 2007–2010 for both courses piloting CBE elements (Figure 23). Historical changes in the courses were summarized and documentation was made about the CBE elements piloted. Results of self-assessments given in the courses and final course evaluations were also summarized for inclusion in a final report for each course.

In preparation for full implementation of CBE across all core courses, six additional questions were added to the student evaluations of every course beginning in summer of 2009 (Figure 24). Results from these new course evaluations, as well as the historical course evaluations from 2007–2010 from non-piloted courses, have been collected for future use. Evidence indicates that results from educational reform initiatives typically take about 5 years to be realized, so evaluating the effects of implementation will need to be an ongoing activity.

Competency-Based Education Implementation
Course Evaluation Questions

Please read each statement. Each item has 5 possible responses. Mark the one response that most clearly represents your degree of agreement or disagreement with each statement. Please respond to all of the statements.

<table>
<thead>
<tr>
<th>Items</th>
<th>Rating Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>The following statements describe your thoughts about learning the fundamental principles of measurement. Please rate your opinion for each of the items.</td>
<td>Strongly Disagree</td>
</tr>
<tr>
<td>1. This course has deepened my knowledge and skills in research design (problem formulation, methodology, measurement, sampling).</td>
<td>1</td>
</tr>
<tr>
<td>2. This course has deepened my knowledge and skills in analytic techniques (statistical methods, data management).</td>
<td>1</td>
</tr>
<tr>
<td>3. This course has deepened my knowledge and skills concerning ethical research practices.</td>
<td>1</td>
</tr>
<tr>
<td>4. This course has improved my oral and written communication skills.</td>
<td>1</td>
</tr>
<tr>
<td>5. This course has deepened my knowledge of professional norms.</td>
<td>1</td>
</tr>
<tr>
<td>6. This course has improved my multidisciplinary teamwork skills.</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 24: Questions added to the end-of-course student evaluations for all ICRE courses

Figure 23: A portion of evaluation results for the Spring 2011 offering of CLRES 2010 Clinical Research Methods
Implementation

**Step 3: Created a Database to Track Core Course Changes**

A database to document both intra-course and inter-course elements was created as part of an effort to track and establish any specific patterns or changes across the ICRE curriculum core (Figure 25). This database will be used to systematically track instructors and assessment activities that occur within and across courses, as well as the broad competency areas that are the focus of a particular course.

This document will allow instructors and course directors to identify specific assessment methods used to address competency domains, as well as identify similarities, differences, and/or changes within and between core courses. Complimentary to course evaluations, which may yield a more specific assessment of courses, this tracking database allows the examination of information that can help to improve course content and structure.

![Figure 25: A portion of the core course tracking database](image-url)
Dissemination
One aim of this grant was the dissemination of the work to other CTS degree-granting programs. This was to be accomplished by presenting the work nationally, serving as a resource for others undergoing a similar process, and publishing articles in relevant journals to the CTS community and beyond. The following is a list of efforts undertaken to achieve that aim:

**Aligned NCRR National Core Curriculum to Virtual University Course**
The project’s Co-Director served as co-chair of the NCRR National Core Curriculum Committee, making contributions to further define and map competencies at a national level.

**Presented at Association for Clinical Research Training (ACRT) Conference in April 2010**
The project team conducted a workshop on CBE at the ACRT conference in April 2010. The workshop consisted of a short presentation about CBE and the steps taken to develop a CBE structure at the ICRE. This short presentation was followed by a facilitated small group session in which groups of attendees discussed the curricular structure at their own institutions, as well as teaching and assessment methods currently being used. Following the discussion section, the larger group reconvened to share general comments about barriers to implementing curricular change.

**Organized a Faculty Seminar on Teaching Methods**
The project team organized a faculty seminar on the effective use of class discussions. This seminar also served a faculty introduction to the newly created CBE curricular structure.

**Preparing CBE Process Paper for Publication in CTS Journal**

**ABSTRACT**

In the emerging field of clinical and translational science (CTS), where researchers use both basic and clinical science research methodologies to move discoveries to clinical practice, establishing standards of competence is essential for preparing physician-scientists for the profession and for solidifying the field of CTS. The diversity of skills (from data manipulation to grant writing) needed not only to navigate but to execute the quality of research necessary within the CTS field has heightened the importance of an educational process that ensures students achieve competence. Particularly within the more applied clinical science disciplines, such as CTS, where there is a multidisciplinary approach to conducting research, defining and articulating the unique role and specific competencies attributable to the physician-scientist is a necessary activity. This paper describes the systematic process of creating and assessing a CBE framework within a graduate program at one institution. The process described in this paper serves an example of how to translate outcomes-based assessment in graduate education, emphasizing the issues and challenges that parallel the broad spectrum of graduate education.
Dissemination, continued

Published Paper on Developing a PhD Program in CTS Journal

ABSTRACT
In an emerging field, such as Clinical and Translational Science (CTS), questions of purpose and educational philosophy become particularly important as programs, competencies, and milestones are developed and become generally accepted as broad national standards. This paper outlines issues programs need to consider as curricula is planned, implemented, and evaluated. It also discusses how philosophy, competencies, and assessments, including milestones, must be intertwined purposefully, with careful attention paid to the integration of knowledge, skills, and attitudes.

Preparing Paper on Assessment in CBE for Publication in CTS Journal

ABSTRACT
Competence is a complex combination of knowledge, skills, and attitudes and, as such, is challenging to assess. Several professions have designed models for assessing competence but this process is done by an outside agency. In disciplines like CTS, there is no accrediting body and the burden of assessing competence is left up to individual institutions. This paper will discuss the development of expertise and its relationship to the assessment of competence, outline the basic tenants of assessment, describe available assessment tools, and explain the importance of aligning individual course assessments and milestone evaluations to an overall assessment strategy that generates a preponderance of evidence for competence.
Barriers to Implementation

Much has been written about the difficulties of implementing comprehensive educational reform. From an agency theory perspective, the difficulty in implementation arises from a lack of conviction on the part of faculty to embrace change because faculty does not share their leader’s vision. This is usually referred to as a lack of faculty “buy-in”. From a social science perspective, lack of implementation usually stems from an aversion to taking risks. This happens when there is no incentive to take risks or no reward for taking risks. Implementation can also fail because the faculty does not understand how to implement the reform. Additionally, some theorists argue that implementation can fail because the leader does not have sufficient oversight of the agents that are carrying out the initiatives to ensure fidelity of implementation.

In reference to the development and implementation of CBE at the University of Pittsburgh’s CTSI, we found that:

- expert knowledge is required to conceptualize the educational process;
- consensus is necessary concerning specific aspects of the educational system that are in need of change;
- alignment of the educational program with the overall mission of the institution or division is critical;
- substantial resources need to be allocated.

Specifically, we found that implementing educational reform was time intensive requiring expert knowledge to:
- conduct literature reviews;
- create theoretical and program specific models;
- develop a project Web site and resource toolboxes;
- disseminate information to instructors.

Implementing CBE without the help of experts in educational planning, teaching, and assessment would be extremely difficult.
Recommendations
Organizational theorists suggest several strategies for improving the probability of successful implementation of educational reform depending on the proposed reason for potential failure. Mission building is suggested as a strategy to increase faculty “buy-in” for the project by increasing the faculty’s commitment to reform. It is argued that risk aversion can be mitigated by creating a culture where rewards are overtly given for risk taking and innovation. In addition, highly specific guidance and training regarding aspects of implementation for which faculty are responsible can help alleviate issues relating to faculty not understanding how to implement a program. In the context of faculty teaching, more oversight could be implemented by instituting peer reviews.

Before attempting to implement a competency-based educational framework, it is important to realize the scope of the project and the resources needed. It requires strong leadership and administrative commitment and support for the educational initiative. Additionally, expertise in the areas of education, curriculum design, teaching and outcomes-based assessment are needed to provide support and training to faculty with respect to the development and implementation of the educational program.

In specific reference to the present development and implementation of CBE at the University of Pittsburgh’s CTS, we offer the following recommendations.

Process Recommendations
• A clear educational mission should be established to inform the CBE curricular structure and provide a framework for the expansion of educational programs.

• All new educational endeavors should be created within the CBE curricular structure. This ensures that the new endeavors (courses, certificates, degree programs) will relate to the established competencies and support the educational reform process.

• A diagram outlining the delivery and connectedness of programs to show the relationship between and among aspects of the ICRE should be created to streamline the educational structure and make delivery of programs more efficient.

• Competencies should be broad enough to accommodate the diversity of the discipline and the goals of individual learners, but explicit enough to evaluate the competence of all learners.

• Competencies should be reviewed regularly to ensure that the nature of the discipline is still reflected in the expectations for learners. This is particularly true for a developing discipline such as CTS.

• Course evaluation questions should reflect the competencies and program objectives so results can inform changes that are needed to improve the educational program.

No one course can provide all the knowledge and skills for any particular content or topic while allowing for sufficient practice to develop competence. Therefore:

• all courses need to show evidence of contribution to several competencies as defined by the curriculum;

• there should be considerable overlap in coverage of the requisite knowledge and skills across courses;

• competencies should be tracked across all courses, regardless of individual learner path, to ensure all of them are addressed sufficiently for all learners during the tenure of their education.
Recommendations, continued

CBE is inherently a learner-centered paradigm. Toward that end:
- choose teaching methods that actively engage learners with the content;
- offer ample practice opportunities to develop skills and knowledge;
- choose assessment methods that require learners to demonstrate their acquired knowledge and skills in an integrated and authentic way.

Milestones reflect the end goal of the educational process. In the CBE paradigm this means milestones should:
- require learners to demonstrate competence in an integrated way in real-life situations;
- be evaluated in a way that measures the degree of competence achieved by the learner.

Implementation Recommendations

Faculty participation and fidelity of implementation are crucial to the success of educational reform. For this reason, faculty should:
- play an active role in the development of competencies and milestones;
- play an active role in program evaluation;
- use results and comments from course evaluations to improve instructional delivery and assessment practices;
- communicate frequently about the tracks and content specializations offered so they understand how their contributions function within the educational program;
- be encouraged to implement CBE in small increments so the change is not overwhelming;
- be trained in teaching and assessment methods that support CBE;
- have access to experts in the field of education to facilitate the necessary changes.

While some faculty will embrace educational reform, others will be hesitant about implementing the necessary changes. It is highly recommended that faculty be incentivized to implement and/or rewarded for implementing.

Dissemination Recommendations

The University of Pittsburgh’s CTSI needs to remain in contact with other CTSIs to:
- disseminate the work done here to help other CTSIs undergoing the same process;
- brainstorm with other CTSIs for solutions to barriers to development and implementation;
- determine if their program is similar to other programs in content and milestones;
- collaborate in defining the discipline and improving the education of future researchers.
References


References, continued


References, continued


References, continued


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References, continued


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Appendices