DEVELOPMENT OF THE CDMIQ EXAM FOR PROGRAM ASSESSMENT AND JOB ENTRY CERTIFICATION OF DATA MANAGEMENT AND INFORMATION QUALITY: A DAMA AND ICCP SPONSORED ACTIVITY OF THE CENTER FOR COMPUTING EDUCATION RESEARCH (CEER) BASED ON IS2002 AND SIGITE 2005 CURRICULA EXTENSIONS

(PRACTICE-ORIENTED)

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ABSTRACT: The Data Management (DM) Association (DAMA) published body of knowledge framework defines the responsibility of Information Technology (IT) professionals across the development life-cycle with respect to the domain of information engineering including information quality. We believe it is feasible to develop an initial skill set in data management and information quality through a set of courses which address these life-cycle elements that

are an extension of either the IS2002 or SIGITE 2005 curricula. DAMA, the Center for Computing Education (CCER) and the Institute for Computing Professionals (ICCP) are hereby announcing the implementation of a new assessment process for such curricular extensions and a certificate, CDMIQ, a "Certified Data Management and Information Quality Specialist" for successful participants. Currently, the CCER produces a web-distributed assessment exam for the Information Systems academic community. Those who pass the exam with a score greater than 50 simultaneously qualify for the ICCP awarded "Information Systems Analyst" certificate. Using path analysis with Lisrel statistical software we are able to demonstrate that curriculum outcomes (learning units, LU) map (by design) to skills expected of graduates by industry. This enables the opportunity for direct outcome assessment with simultaneous skills assessment. During the next year, a consensus based process will determine a set of outcomes compatible with the national curriculum models that can be mapped to the DAMA identified skills including both data management and information quality skills expected of Novice DM professionals. Additionally, the CCER will solicit volunteers in the development of the assessment/certification exam, and the ICCP will inaugurate the new CDMIQ certificate.

KEYWORDS: Information Quality, Data Management, Certification, Assessment, Curriculum , ICCP, CCER

INTRODUCTION

The data management profession is a group of professionals having on the average in excess of 20 years of experience[20]. Most of its members have had ten years of prior business and information systems experience before being hired into their profession. Indeed, data management is therefore regarded as an "elusive profession" [20] since the entry level requires so much prior experience. The profession is represented through the Data Management Association (DAMA). As a service to the computing profession, DAMA developed its Curriculum Framework and its DMBOK [8,9] (data management body of knowledge, see Figure 1).

"Information Engineering": Skills of Data Life Cycle Management

- Data Information Governance and Stewardship
- Data Requirements Analysis and Documentation
- Data Modeling, Access and Security
  - Planning for Data & Metadata
  - Data Quality
  - Data Models and Modeling
  - Relational Data Model
  - Data Warehousing
  - Data Security
- Physical Database Access and Management
  - Data Storage Management
  - Data Access and Database Programming
  - Database failures, backup and recovery procedures
- Standards Creation, enforcement, maintenance

Figure 1. Abstraction of the DAMA Framework Body of Knowledge [13,14]

Recently, we observed [13] that the skills of the DMBOK Framework [8,9] can be arranged in life-cycle order. We presented a graphical representation, Figure 2, showing the skills in comparison to other computing disciplines including Systems Engineering, represented as a profession by INCOSE, Software Engineering, represented by SEI. In this graphic, shown with compliance to the CMMI [1,2,3], each skill element of the DMBOK is portrayed somewhere within the developmental life-cycle of information engineering activities. Similarly, INCOSE and SEI would specify their respective rows.

It is likely that professional systems engineers, professional software engineers, as well as professional data management people occupy the workforce in large organizations. It is also likely that few of these professions exist in smaller organizations. In smaller organizations none of these professionals will be found. Instead, information systems professionals may well take responsibility for all three of these professionals.

CMMI Technical Policy	1.4.1 System Initiation	1.4.2 Systems Analysis and Design			1.4.3 System Component Design		1.4.4 System Implementation		1.4.5 System Integration, Test and Evaluation		1.4.6 System Operation and Support		System Evaluation	System Maintenance
Systems Engineering INCOSE	System Feasibility / System Planning	System Reqmnts Analysis	System Design Interface Identification	Verification, Validation and Certification Test Plan	Verification with customer of reqmnts	Verification of detailed design	Module validation with customer review	Application Validation with customer review and acceptance	System Reqmnts Validation	Final System Evaluation	System Acceptance and operation validation	Initial Operation; Post Implementation Cleanup; Certification	System Performance Review	Evaluation of Customer Satisfaction and CSF Attainment
Information Engineering DAMA	Data / Information Governance and Stewardship	Information Reqmnts	Data Base and Warehouse Architecture	Data Reqmnts Analysis / Metadata Reqmnts Analysis	Database Table & Stored Procedure Identification	Detailed Design & Database Scripts; DQ Planning	Stored Procedure & Trigger Construction & Testing	Conversion Planning and Construction	Conversion Testing	Data Evaluation	Database Deployment; Data Conversion Configure	Database Admin; Backup and Recovery Deployment	Capacity Performance & Quality Review	Database Admin: Access Mgt Backup Recovery
Software Engineering SEI		Software Systems Analysis	Software Systems Design	Software Rqmnts Analysis	Software Module (Page and Reports) Design	Detailed Software Layout (Screens & Reports)	Software Construction & Module Testing	Software Integration Testing	System Integration	Software Evaluation and Certification	Software Installation and Testing	Software Maintenance	End User Software performance analysis	Software Maintenance and Updates
Business Process	Customer Reqmnts Analysis / Business Plan	Business Goals and Objectives	Business Policy	Stakeholder Analysis	Work Flow Procedure Writing	Job Design	Procedure Manual Construction	Business Conversion Planning	Business Process System Support Evaluation	Final Acceptance Review	Job Training	Business Cutover and Initial Operation	Customer Satisfaction and Business Objectives Review	Customer Satisfaction And Business Process Efficiency and

Figure 2. Life-cycle Relationships between Systems Engineering (INCOSE), Information Engineering (DAMA), highlighted, Software Engineering (SEI), and Business Process Development. [22,13]

In the professional world of the data management professional, problems tackled are of a large enterprise nature spanning perhaps a multi-billion dollar organization. The responsibility for management of information at this level is in sharp contrast to that managed by a college senior who may have very limited professional experience. For the student, establishing a data architecture for General Motors, for example, would not be within the realm of understandability. Similarly, the data management professional is constantly concerned not with knowing about information quality, but in achieving and improving it on a regular basis. DAMA has fully embraced this evolving mission. Indeed, the concept of CMMI as applied to data management was presented by Peter Aiken at a recent DAMA conference[1] . Likewise, for systems engineers and software engineers, the Capability Maturity Model Integrated (CMMI) [2] quality model is of major importance in overcoming the failures documented by the Standish Group and even striving for defect free systems.

[1] Aiken, Peter (May 2005). Assessing Data Management Maturity (DM3). Presented at the Wilshire Meta-Data Conference / DAMA International Symposium , Orlando.

1. Data quality, data architecture, and metadata should be integrated into the database course. These are skills that must be part of the tool-set of any information systems professional. Data modeling must include consideration of information quality concerns. SQL scripts, queries and stored procedures and triggers development skills are very important. It may require an additional course to cover the concepts and practice of ensuring data quality.

2. A course in data warehousing concepts should be added. Practical tools such as ETL and reporting tools such as Crystal Reports should be practiced and become true skills. Warehouse design can be covered minimally. For example, a star schema can be implemented, and conversion routines practiced from multiple source types, spanning a variety of conversion and data quality issues. If an institution has an established decision support systems (DSS) course, this course could be expanded to include the concepts and techniques of data warehousing. However, the practical focus must be maintained.

3. A course in data mining concepts with limited practicum should be offered. Concepts of business intelligence can be integrated into this course. Reporting tools should be practiced. Inference tools can be included. Statistical tools can be included. Alternatively, an existing DSS course could be enhanced to include the concepts and limited practicum for data mining.

Figure 3. Technical Course Content Recommendations for A Professional Focus Area in Data Management For an Information Systems Curriculum. [13, with modifications**]**

However, there is a disconnect between the graduate of the academic world and the functioning professional with a minimum of ten years of experience. We are not proposing a remedy for instant success as a data management professional. Yet, like the arrow fired by the archer, the initial direction will make a significant difference in the arrow finding its target. Also, like with the archer, what can be measured can be improved. The thesis of this paper is that direction can be supplied [13] with a well crafted set of data management and information quality courses (see Figure 3).

Skill	Description	Job Ad Words
1.3.1	**Modeling and design, construction, schema tools, DB Systems**	modeling, SQL, construction, tools -top down, bottom up designs; schema, development tools; desk-top/enterprise conversions; systems: Access, SQLServer/Oracle/Sybase, data warehousing & mining; scripts, GUI tools
1.3.2	**Triggers, Stored Procedures, Audit Controls: Design/ Development**	triggers, audit controls-stored procedures, trigger concepts, design, development, testing; audit control concepts/standards, audit control implementation, T-SQL, PL/SQL
1.3.3	**Administration: security, safety, backup, repairs, replicating**	monitoring, safety -security, administration, replication, monitoring, repair, upgrades, backups, mirroring, security, privacy, legal standards, HIPAA
1.3.4	**Metadata: architectures, systems, and administration**	definition, principles, practices, role of metadata in database design, repository, dictionaries, creation, ETL, administration, usage, tools
1.3.5	**Data Warehouse: design, conversions, reporting**	star schema, ETL, data cleansing and storage, reporting tools, business intelligence, analytic queries, SQL OLAP extensions, data mining
1.3.6	**Data Quality: dimensions, assessment, improvement**	Data Accuracy, Believability, Relevancy, Resolution, Completeness, Consistency, Timeliness; Data definition quality characteristics, Data model / requirements quality characteristics; Data clean-up of legacy data, Mapping, transforming, cleansing legacy data; Data defect prevention, Data quality employee motivation, Information quality maturity assessment, Gap analysis, data governance and stewardship

Figure 4. Data Management and Information Quality Skills Appropriate to a Data Management Professional [13] (Skills 1.3.1, 1.3.2, and 1.3.3 are specified within the IS2002 Model Curriculum [4,5,6,7,10]. Skills 1.3.4-6 were derived [13] from the DMBOK [9] and were recommended along with Skills 1.3.1-3 as a complete picture of skills needed by a data management professional.[9])

We are suggesting the DMBOK provides an excellent description of the target: The expansion to the IS2002 skill set [10] resulting from the projection of the DMBOK onto the IS2002 skills (see Figure 4)

was presented to the community [13]. This framework will provide the basis for developing the details necessary for precise identification of the target and an accurate measurement mechanism. While several courses may not generate a ten year veteran professional, it is a good first step. As such, it is recommended that the additional depth attained through this course work be assessed by the CCER, and that those achieving a certain level of proficiency be eligible for the proposed CDMIQ certification by the ICCP.

CAN CDMIQ COURSEWORK COEXIST WITH IS AND IT CURRICULA?

There is a great similarity between the information systems curriculum and information technology outcome skill set, although the goals of the programs are quite different as are the mechanisms of curriculum specification. The skills that were determinant for IS2002 were isolated from newspaper job ads for all computing jobs. These words were grouped, abstracted, and utilized as the basis for a national survey [10]. Participants including mostly academics and some industry professionals self classified themselves as IS, IT, or DM professionals. Factor analysis yielded 37 sub-skills [10] that were shared among the three computing areas (See Figures 6 and 7).

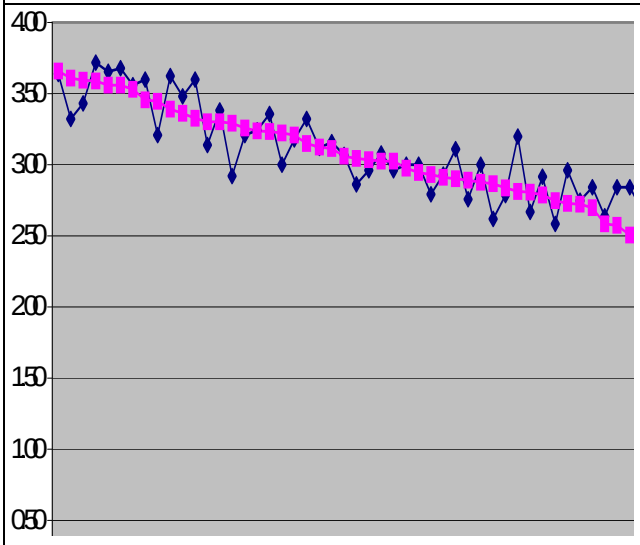
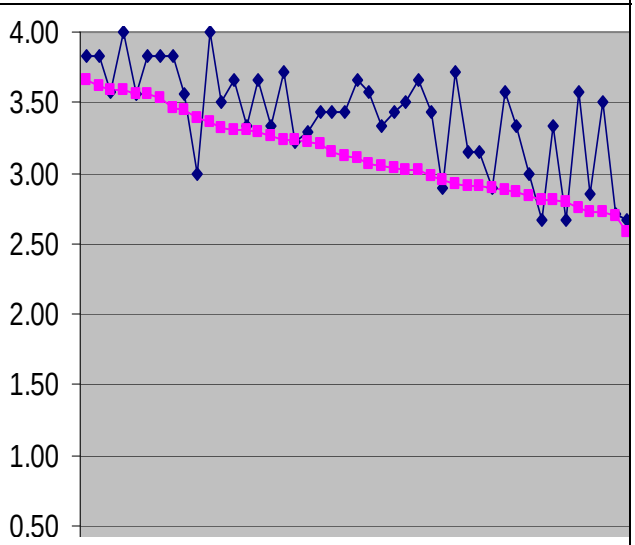
IS vs. IT	IS vs. DM
Skill Depth is plotted in descending order for IS and IT skills. The data are ordered in IS order (The smoother line represents IS skills). Although the goals of the two disciplines are very different, skill depths expected are essentially the same.	Skill Depth is plotted in descending order for IS and DM skills. The data are ordered in IS order. (The smoother line represents IS skills) The ordering of skills is roughly similar, however, DM is consistently higher for most skills
	

Figure 6. Similarities between IS, IT and DM Undergraduate Outcomes

We show this skill analysis to indicate that because of the similarity of skills between the two programs, and also to show that expectations for DM graduates should only require minimal additions to the curriculum to reach desired skill levels. IS2002 was designed with a fixed architecture 1) to produce a generalist, and 2) to fit within the restricted ten course limitation of AACSB business school programs. However, since more than 50% of information systems programs exist outside schools of business this course limit restriction is not an issue, and it would be easily possible to add several additional courses. AACSB schools might combine IS1 and IS3, or use computer science courses for IS4, IS5, and IS6 to

free up curriculum space. The SIGITE 2005 model curriculum has anticipated that specialty areas exist in order to complete the degree program. Since the SIGITE curriculum contains little systems analysis or business specifications, some course work in these areas would be indicated. There is ample curriculum space to accommodate such a recommendation. Both IS and IT programs would have to assure practical experience to achieve the higher levels of Team and Personal skills development (see figure 7) expected. In fact many IS and IT programs already offer a second database or database administration course as well as coursework in data-warehousing. New material will have to be introduced to ensure adequate coverage of information quality.

Skill Description	IS	DM
DB-administration	2.75	3.57
DB-db development	3.24	3.71
DB-modeling	2.93	3.71
IRM-Info resource mgt	2.81	3.33
IS.MGT-IS function	2.72	3.50
IS.MGT-project tracking	3.03	3.67
SAD-accounting, distribution	2.87	3.33
SAD-business problems	3.30	3.67
SDevl-sys documentation	3.06	3.57

Skill Description	IS	DM
IS.MGT-project tracking	3.03	3.67
PERS-accountability	3.11	3.67
PERS-commit/completing	3.59	4.00
PERS-design	3.29	3.67
PERS-interpersonal skill	3.36	4.00
PERS-methodology	3.03	3.50
PERS-self direction	3.46	3.83
PERS-use of theory	2.13	2.50
TEAM-continuous improvement	2.88	3.57
TEAM-life cycle mgt	3.04	3.43
TEAM-specify/deploy	2.98	3.43

Figure 7. Necessary Skills in Addition to those associated with an IS Curriculum. Column 1 -- IT Skills, Column 2 -- Team and Interpersonal Skills. (Skill depth levels were 0 to 4. 0=no-skill, 4=application knowledge level. The table shows skills wherein the difference > 0.4 for required DM skills vs. IS.**)**

DEVELOPMENT OF VALIDATED COURSE OUTCOME STATEMENTS

During the next year the co-authors of this paper will conduct a national study to develop a set of outcome statements reflecting the desired skills. It will be necessary to assure that academics can identify courses for which the outcomes are reasonable. Simultaneously, a skill outline must be developed using the DMBOK as well as skills from the previous survey data. The skill outline will have to be validated with DAMA members who will have knowledge of professional expectations of a DM Novice. Then, to ensure that there is a threaded sequence of outcomes, assessable objectives will be identified and written (See Figure 8). These assessment objectives are the basis for developing items for the new CDMIQ exam.

DEVELOPMENT OF THE CDMIQ CCER ASSESSMENT EXAM

In order to develop an effective exam, a sufficient number of items must be developed to evaluate each assessable objective. Therefore, vigilance must be maintained to be careful in the specification of outcomes as well as skills. If there is too much abstraction (just a few skill and outcome statements), the data may not have meaning. Likewise, if there is too much specification (many outcomes and skill statements), there will be a necessity for too many items to ensure valid measurements, and no one will sit through the exam.

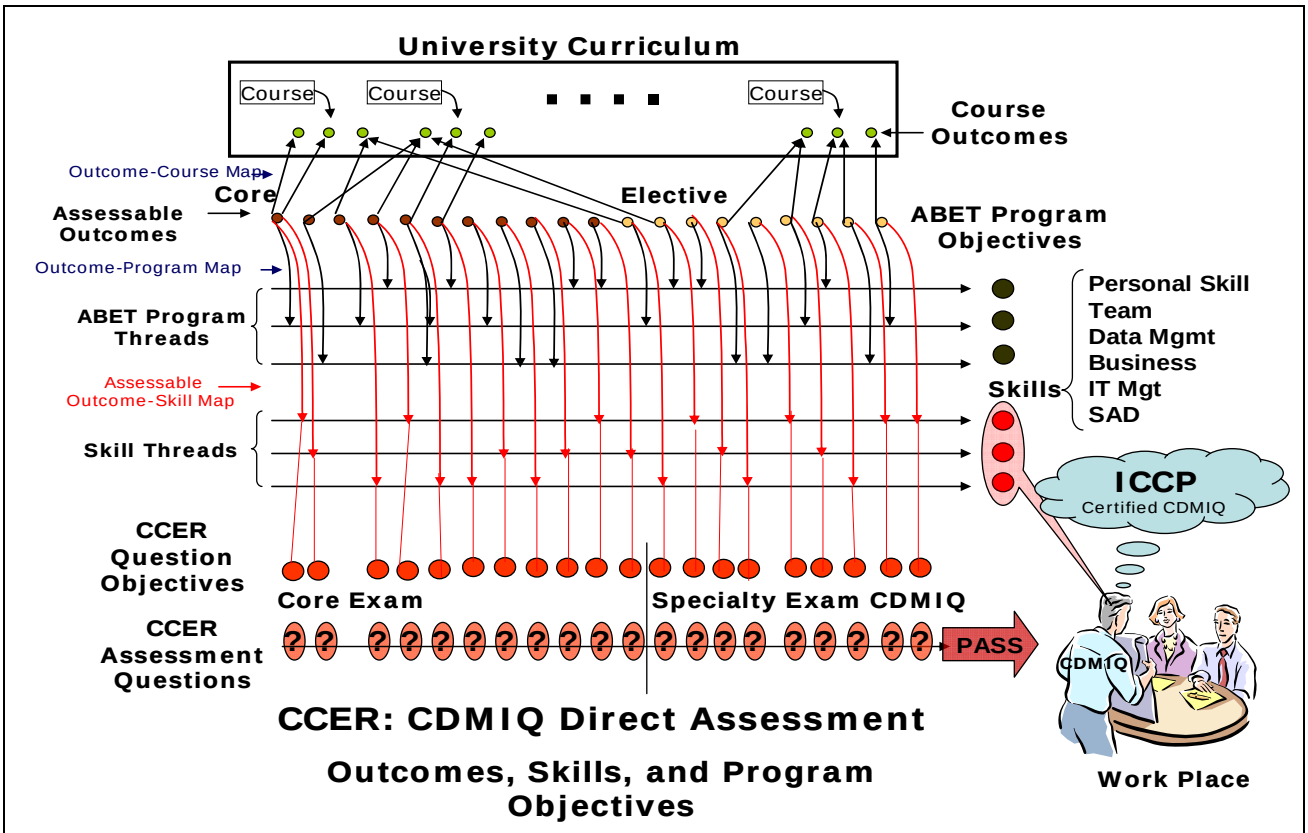
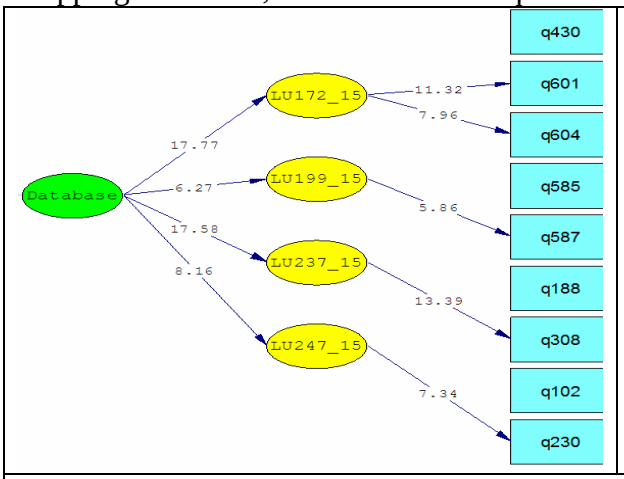


Figure 8. CCER Assessment Model

With the CCER ISA [11,12,15,16,17,18] exam there were 60 learning units (outcomes) mapped to 8 skills with a total of 37 sub-skills. It was possible to ensure that there were at least 4 questions to assess each outcome, and at least 4 questions to assess each sub-skill. Due to the mappings involved, 258 items were required to examine all of the outcomes and sub-skills.



ID	LU #	LU Goal
172	15	to present and apply strategies for accessing and using information resources
199	42	to present the concept that data is a representation and measurement of real-world events
237	81	to develop application skills for implementing databases and applications by operating and testing these databases
247	91	to develop skills with application and structuring of database management systems

Figure 9. Use Of Lisrel To Show That Related LU's Significantly Predict Database Skill (Id=15), And Related Test Question Results Significantly And Positively Predict The LU's

(The data represented in the figure comes from the CCER ISA[17] exam data. The numbers shown along the arrows are "t" scores, n>2000. The four ovals are LU-Skill pairs. The rectangles represent a specific test item. The meaning of these results is that the examiner's intent was realized with a high degree of significance.)

Figure 9 is a demonstration of the validity of the mapping process based on Lisrel path analysis. Items directly mapped to LU's which in turn mapped directly to the skill. This technique is similar to factor loading: the questions loaded on the learning units which loaded on the skill. There were insufficient items to show the mapping at the sub-skill level, however.

THE NEXT STEPS

During the next year all of the steps shown in Figure 10 will be accomplished by joint effort of the co-authors. A combination of survey and conference call methods will be utilized to complete these tasks. Participants will be solicited at the fall information systems and information technology meetings. The CCER and DAMA will coordinate the overall process. The coordinating mechanism will be an on-going email thread.

Step	Project…Activity	Description of Activity
1	Skill Validation	The IS2002 skill [10] set has been updated using the DAMA and INCOSE bodies of knowledge. Also, the skill set has been updated based on a thorough study of the SIGITE curriculum. Earlier studies will also be incorporated [21]. DAMA membership will be solicited to review the proposed skill outline for the CDMIQ certificate by survey.
2	Review Existing Courses	Courses in Database, Database Management, Data Warehousing, and Information Quality will be collected and studied to determine known working course models. Topics, Outcomes, and other information will be collected.
3	Identify Needed Courses	While we suspect at most 3-4 courses should be specified, we plan to listen to our academic colleagues to explore which courses are effective and essential. We will compare this information with the review.
4	Identify Outcomes for Early Courses	We suspect that either the IS or IT curriculum will provide a sufficient richness that a threaded sequence of skills will be traceable back to earlier courses. If this in unsuccessful we will develop outcome statements that should be included within earlier courses. For example, information quality could be introduced in a general principles course as well as database and SAD courses.
5	Develop CDMIQ Skill Outline	A final skill outline will be constructed based on survey data and based on the number of probable outcomes and the number of mappings. The potential psychometric consequences of the outline, outcomes, and mappings will be finished.
6	Finalize Relevant Outcomes and Map	As the skills and outcomes are finalized, the outcomes must be mapped to the skills showing both the skill thread as well as the definition of assessment points
7	Create Assessment Objectives	For each assessment point an assessment objective must be developed to capture both the emphasis of the outcome as well as the meaning of the skill
8	Develop Items	Multiple and redundant items will be developed for each assessment objective. The items will be tested to ensure selection of questions with a high (>0.3) point-bi-serial correlation coefficient.
9	Beta Test Exam	A beta exam will be administered to more than 200 volunteers to calibrate the exam. The psychometrics of the exam will be evaluated to select the final item set.
10	Develop Certificate Process	Testing and certification procedures will be developed. Coordination between the CCER and ICCP will be tested. Updated reporting procedures for examination sites will be developed.
11	Launch Exam	The exam will be released by the CCER to the academic community, and by the ICCP to the professional community.

Figure 10. Stages in Creating the CDMIQ Assessment and Certification Exam

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