The Science of Learning, would you like a side order of Quality with that?

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ABSTRACT

Quality – 1. The essential character of something; 2. A distinguishing characteristic; 3. Superiority of kind; 4. Degree or grade of excellence; 5 Degree to which a set of inherent characteristics fulfills requirements.

The Science of Learning provides great insight upon which to build effective and efficient courseware, but what about the development of that courseware? Is there a way to develop instructionally sound courseware that meets prescribed specifications to ensure portability and reusability while applying the ISO 9001:2000 quality standards to the development process? Some would argue that doing this essentially reduces the development of courseware to a production line process. Instructional Designers fear the loss of creativity and would argue it can't be done because they need free reign to apply the Science of Learning. Industry would argue that applying standards would rob them of their uniqueness and government personnel have a hard time understanding the principles of ISO 9001:2000.

Broken down into its basic processes, the design and development of courseware IS a production line process. Additionally, it is well understood that the application of the ISO 9001:2000 model works extremely well in a production environment. This paper discusses the fundamentals of a quality management system as the business strategy for production of instructionally sound courseware. More specifically: What is an ISO 9001:2000 Quality Management System and how can it be applied to Courseware Design and Development.

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INTRODUCTION

The Science of Learning provides great insight upon which to build effective and efficient courseware. At its core, the Science of Learning seeks to understand how individuals and teams acquire the competencies needed to perform their job (Gunn, 2001). Over the past 50 years, learning theorists from the three major epistemological traditions (i.e., behaviorism, cognitivism, and constructivism) have presented numerous learning theories that describe the process of learning.

What about the design and development of courseware? How does one ensure courseware designers and developers employ processes that continuously meet customer requirements and consistently adhere to prescribed standards and specifications to ensure portability and reusability?

Broken down into its basic processes, the design and development of courseware can be considered a production line effort. Additionally, it is well understood that the application of the ISO 9001:2000 Quality Management System (QMS) model works extremely well in a production line environment. This paper discusses the fundamentals of a quality management system as the basis of a business strategy for production of instructionally sound courseware. *Note: We understand and acknowledge that analysis is an essential step in the design and development of courseware; however, it has not been addressed in this paper due to space constraints.*

WHAT IS AN ISO 9001:2000 QUALITY MANAGEMENT SYSTEM?

The International Organization for Standardization (ISO) is a worldwide federation of national standards bodies. The ISO 9000 family is primarily concerned with "quality management" or what an organization does to fulfill their customer's quality and applicable regulatory requirements and aims to enhance customer satisfaction (i.e., the perception of the degree to which the customer's requirements have been fulfilled [ANSI/ISO/ASQ Q9001:2000]) and achieve continual performance improvement in pursuit of these goals.

ISO 9001 specifies requirements for a QMS that can be used internally by organizations for certification or for contractual purposes. It focuses on the effectiveness of the QMS in meeting customer requirements. "2000" refers to the year this new standard was adopted.

The adoption of a QMS is a key strategic decision because its design and implementation requires a major cultural shift in the way an organization does business. When adopting an ISO 9001:2000 QMS, the goal is to improve product effectiveness and efficiency by developing and implementing a process-based quality management system to enhance customer satisfaction and meet customer requirements.

For an organization to function effectively and efficiently, it must identify and manage numerous linked activities. A process is a series of actions, changes, or functions that bring about an end or result (American Heritage Dictionary, 1982); therefore, any activity that uses resources and is managed to enable the transformation of inputs into outputs can be considered a process. Often, the output from one process directly informs the input to the next. The application of a system of processes within an organization, together with the identification and interaction of these processes and their management can be referred to as a "process approach."

One advantage of a process approach is the ongoing control it provides over the linkage between individual processes within the system, as well as over their combination and interaction. When used within a QMS, this approach emphasizes the importance of:

- Understanding and meeting requirements.
- Considering processes in terms of added value.
- Obtaining results of process performance and effectiveness.
- Continual process improvement based on objective measurements.

The following model of a process-based QMS illustrates these linkages and shows that customers play a significant role in defining requirements as inputs. Monitoring of customer satisfaction requires the evaluation of information relating to the customer's

perception of whether the organization has met their requirements. This model covers all requirements of the ISO 9001:2000 standard but does not show processes at a detailed level.

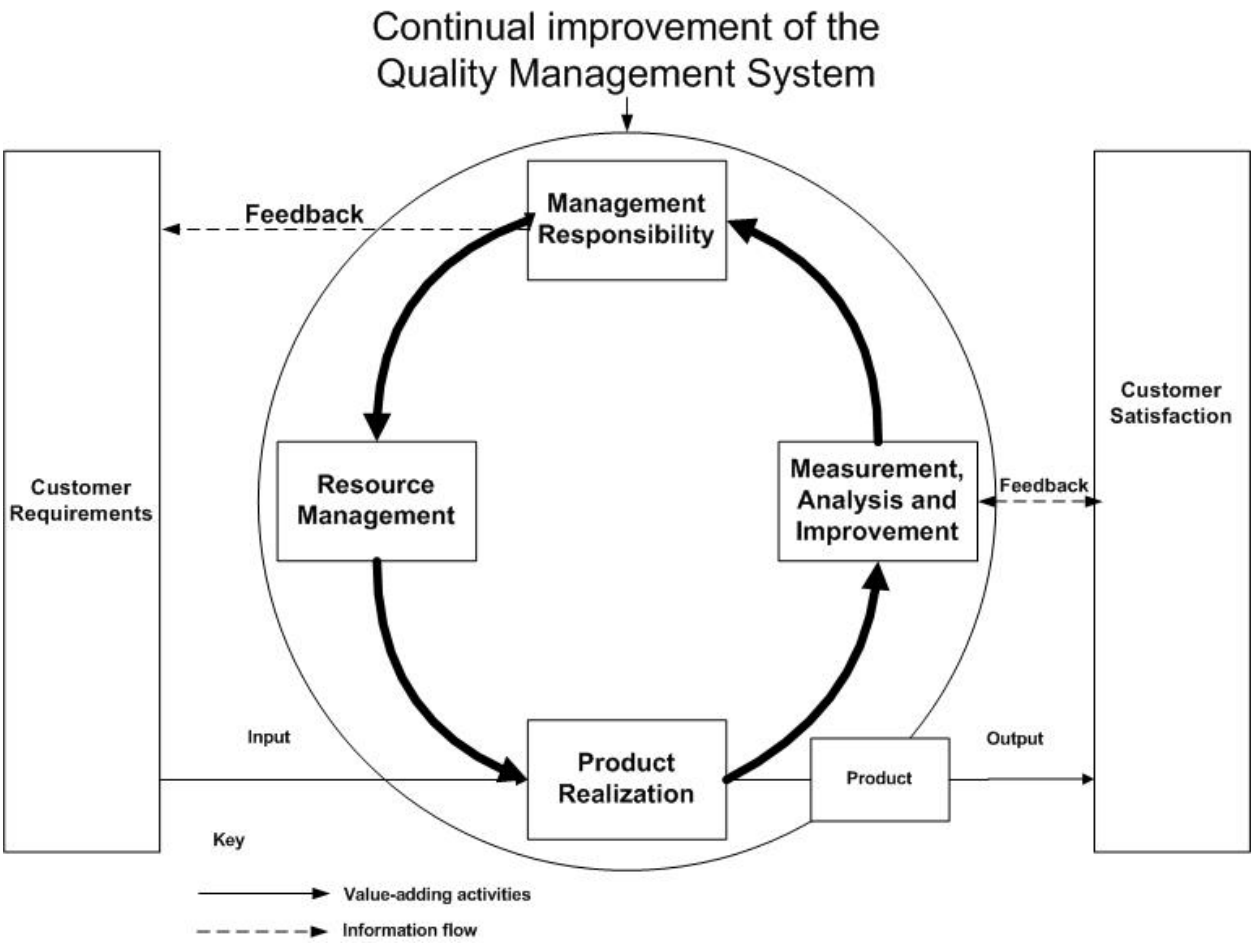

Figure 1. Model of a Process-Based Quality Management System

In conclusion, the ISO 9001:2000 standard specifies requirements for a QMS where an organization

a. must demonstrate its ability to consistently provide products that meets customer and applicable regulatory requirements (i.e., SCORM 2004, Section 508, etc.), and

b. aims to enhance customer satisfaction through the effective application of the system, including processes for continual improvement.

QUALITY AS A BUSINESS STRATEGY

Many people view the implementation of a QMS as costly and time consuming and so are initially anxious about the idea. The key is to modify one's perspective: quality and business are synonymous, not two separate concepts.

In its purest definition, quality is the degree to which a set of inherent characteristics fulfills requirements (ANSI/ISO/ASQ Q9001:2000). When creating a business plan, most companies quickly come to the same conclusion - quality and perceived value are the two most important factors to achieving success. So, if quality is the driving force behind a company's business strategy, how can companies offer better quality and better services than their competitors?

In the last ten years, the training industry has evolved in terms of technology, education, and specialization. The new focus is to engineer quality into developed products to ensure necessary levels of quality are

achieved, to make the achievement of quality predictable and repeatable, and to minimize endeavor, organizational, and personal risks (Firesmith, 2004).

Quality is a Verb, not a Noun

Let's take a quick look at what history can teach us about engineering quality into products. The United States came out of World War II as the only major industrialized nation with its manufacturing sector completely intact. A robust manufacturing sector and an abundance of raw materials helped the US become a leader in the production and export of durable goods. While the US was enjoying its position as the world's preeminent manufacturer, the other industrialized nations of the world, particularly Germany and Japan, were busy rebuilding. As they did, two things became apparent:

1. To succeed they would have to compete globally.
2. To compete globally, they would have to provide world-class, quality goods (i.e., produce better goods at a more competitive price).

Resting on their laurels, US manufacturers were slow to catch on that the game had changed from mass production with acceptable levels of waste to quality production with things done right the first time, every time. The new game was best cost AND best quality. By the time US companies realized that quality was the new key to success in the global marketplace, Japan, Germany, Taiwan, and Korea had made major inroads into global markets previously dominated by US manufacturers (i.e., steel, automobiles, computers, and consumer electronics) [Goetsch & Davis, 2004].

Show Me The Money!

"OK, I want to address quality but it costs too much money!" From a business perspective, the reason to focus on quality is to realize a net gain in profit. From a training perspective, engineering quality into training products streamlines procedures and ensures consistent and reliable outcomes. In addition, customer satisfaction is enhanced because a process is in place to ensure QA requirements are met every time. The "cost" qualifier is actually the net gain realized when you don't have to constantly spend time, money, and effort making corrections. Like any investment, quality engineering should return more than it costs.

HUMAN PERFORMANCE IS THE BUSINESS OF TRAINING

"Training Transformation" describes the Department of Defense's (DoD) training initiative, changing the way that training is developed and delivered, with the ultimate goal of enhancing the performance of each trainee. Within DoD, training is becoming a learner-centric endeavor; e-learning is transitioning to "me"-learning. That is, training is envisioned to be tailorable to the individual by assessing existing capabilities, performing task and skills analyses to determine training required for an occupational specialty, and delivering a blend of training solutions to provide optimum learning. The proliferation of internet-based technologies and the need to share data electronically in a reusable, standardized format are driving the development of sharable content repositories in distributed databases where learning chunks can be used in multiple formats delivered anytime - anywhere. With a smaller DoD workforce and the need to deploy forces to multiple locations worldwide, the time available to train has been shortened, and training system acquisition cycles have been compressed.

Navy training is undergoing a major cultural shift to now focus on the Sailor, not on hardware; and a shift away from a group-paced, criterion-referenced, instructor-managed methodology, to learner-based, problem-oriented, on-demand, web or PC based, mentor-assisted training. Use of traditional and even more recent content development models has focused on single courses of instruction with singular training objectives and supporting media. Under the "Revolution in Training" (RIT), knowledge, skill, and ability clusters known as competencies are recognized as pertaining to larger communities of practice with recurring needs across operator and maintainer communities regardless of ratings. In this new system, the individual sailor with his or her own unique knowledge, skills, and abilities is mated with the skills required to operate a piece of equipment or deploy a ship or squadron. As a result, manning requirements in mission dedicated organizations like ships and squadrons find themselves in the unenviable position of seeking sailors who have the requisite training in mission requirements that are constantly changing and are poorly defined. This is especially true when fielding new weapons systems where development, production, and installation take precedence over the development and deployment of the training solution necessary to operate them (Gunn, 2001).

To counter what many believe to be a quandary in Navy training (i.e., the technological challenges stated above as well as increasing competition from the private sector for high quality recruits), the Navy is seeking to corral training solution challenges by focusing on the individual sailor as the critical asset and tailoring training solutions to accommodate instruction when and where required. Tailoring instruction to the individual, the Navy believes, requires a change in perspective to focus on human performance. Toward that end, the Navy is combining the Science of Learning and industry-tested, process-based quality assurance measures to improve how individuals and teams come to acquire competencies needed to perform their jobs." (Gunn, 2001).

In the Executive Review of Navy Training (ERNT) chartered by the Chief of Naval Operations (CNO) to develop a strategy and implementation plan for revolutionizing Navy training, the focus on human performance is realized by developing a sailor's competencies as defined by the sum total of their knowledge, skills, and abilities. These three competencies are more narrowly defined as "Knowledge,…the underlying rules, facts, relationships, procedures, and vocabulary that support effective performance; Skills,…the person's capability to execute an appropriate sequence of behaviors; and Abilities…preferences, talents, strengths, attributes and attitudes (Gunn, 2001)."

Given the focus on human performance, the Navy has looked to the Science of Learning to understand and capitalize on how individuals and teams come to acquire the competencies they need to perform their jobs. Science of Learning research suggests that individuals retain knowledge best when they learn theory while applying it; individuals internalize complex information at higher rates when they learn it in a collaborative environment; and learning is maximized when organizational structures are aligned. Tenets of the Science of Learning accepted by the ERNT include:

- Optimal instructional design requires a comprehensive needs assessment.
- Tailored instruction is more effective than group-paced instruction.
- Building confidence in learners is an important outcome of training.
- Developing learner self-awareness supports the learning process.
- Measurement and feedback are paramount to sustaining effective learning.
- Learning is a continual process.
- Blended human performance solutions result in the greatest improvements (Gunn, 2001).

Research indicates that motivation also has a significant effect on individual learning. Students, who are proactive in their learning, learn more and learn better than people who wait to be taught. They enter into learning more purposefully and with greater motivation and tend to retain and make use of what they learn better and longer (Knowles, 1975).

Factors that motivate students include relevance of the material and the degree the training can help the learner succeed. Learner motivation is increased when engaged in the learning process by way of hands-on training, practice, and discussion. Learner motivation is further enhanced when the learner is self aware of their own mastery in the learning process through the use of measurement and feedback and is better able to diagnose their own needs and direct their own learning processes. This is consistent with the theory that "optimal professional development occurs when the environment facilitates the work necessary for the person's conceptual growth. When environmental conditions are not optimal, then some form of arrestation is assumed to occur (Harvey, Hunt, & Schroder, 1961)." In other words, as the individual becomes more complex, the environment needs to change with him or her if growth is to continue at an optimal rate. This perspective serves two purposes: one, controlling the learning environment keeps people growing conceptually. Second, since people are at different stages of development and respond differently to various models of learning, the system must match learning strategies to the learner's development (Hunt, 1970).

COURSEWARE DESIGN AND DEVELOPMENT BUSINESS STRATEGY

Courseware was traditionally developed for use by instructors and students to augment information learned in the classroom and/or contained in textbooks. Content to be learned was found in the text and it was the instructor's responsibility to "teach" that content to the learners. Teaching could be interpreted as getting content from the text into the heads of learners in such a way that they could retrieve the information for a test. Given this model, the way to improve instruction was to either develop the instructor by requiring him or her to acquire more knowledge or by using courseware to convey additional knowledge to the learner.

A more contemporary view of instruction, though not necessarily new, is that of a systematic process where

every component (i.e. teacher, students, materials, and learning environment) is crucial to successful learning. This process view of courseware development assumes that the sailor's knowledge, skills, and abilities; their pay, advancement, and professional and personal development; and job tasks required by end use weapons or platform-specific systems are a set of interrelated parts, all of which work together toward one defined goal - Mission Readiness.

The parts of the courseware design and development process rely upon each other for input and output, and the entire process uses feedback to determine if the desired outcome has been reached. If the process does not achieve the desire outcome, then it is modified until it reaches the goal. Following successful achievement of the goal, the process is continually modified and improved to mitigate inefficiencies and anticipate or account for change (Dick & Carey, 1990).

The development of courseware has long relied upon a systematic process of analysis, design, development, implementation, and evaluation. Tasks occurring within the design phase include:

- Creation of learning objectives.
- Development of test strategies and tests.
- Determination of instructional strategies.
- Selection of instructional methods and media.
- Review of existing instructional materials (objects) and raw media to determine their applicability to the specific instruction under development.
- Production of the implementation plan for the instructional system, and,
- Design of a training information management system.

Development phase tasks include:

- Development of courseware, lesson materials, assignment sheets, job aids, and other instructional materials for both the student and the instructor.
- Production of media selected during the design phase.
- Update of the implementation plan, and,
- Validation of instructional materials as they are developed.

Further, the developed content must include the capability to customize training to individual abilities married with equipment or weapons system requirements while still facilitating the assessment, recording, and synthesizing of personal and professional development of the individual.

The systematic process of courseware design and development today also includes technical requirements and performance specifications to ensure the operation, interoperability, and security of the courseware and to facilitate the distribution of content over web-based and server-based entities. For example, new Design Phase requirements include:

- Design of Reusable Instructional Objects (RIOs)
- Aggregation of Reusable Learning Objects (RLOs)
- Sequencing of content for use with a Learning Management System (LMS)/Learning Content Management System (LCMS)

New Development Phase requirements include:

- Writing and assigning instructional metadata to objects
- Creation of a System Security Authorization Agreement (SSAA) plan
- Packaging of content for SCORM™
- Validation of manifest properties
- Building a content package for hosting on a web portal

With this added burden of adherence to technical requirements and specifications comes the need to guarantee the quality of the end product. Toward that end, lessons learned by industry through the quality revolution of the 1980s and 90s can be applied to the schematic that defines the processes through which academic products are tailored to fit the needs of the customer. The products in this case are courseware and the customer is the sailor.

Resistance to a strict process of courseware development focuses on the loss of creativity during design and development, the minimization of instructor interaction with students, and the utilization of simulation in areas previously supported by actual equipment. The instructor asks, "How can you teach someone to rivet, solder, or manipulate a cannon plug via computer simulation?" Aside from the nature of the question, the fallacy is the embedded assumption that all teachable skills can and will be simulated. The Navy is presented with the challenge of keeping courseware current within an accelerated schedule of weapons system development and deployment without the guaranteed presence of an instructor, the time to send a sailor to a schoolhouse, or the money to maintain every type/model/series of system. To meet this challenge, the traditional process of courseware

design and development must be combined with technical standards of performance that force content to be accessible, operable, resident electronically, and readily modifiable to suit the unique conditions of a deployable Navy.

COURSEWARE DESIGN AND DEVELOPMENT APPLIED TO THE ISO 9001:2000 MODEL

The ISO 9001:2000 model of quality assurance has been applied by industry to organizations that design, develop, produce, install, and service products. ISO 9001:2000 is a quality assurance model made up of five core processes with multiple sub-processes. The ISO model, as applied to courseware design and development, offers a process-oriented approach to the systematic design and development of courseware and also accounts for customer-centric requirements and technical performance specifications. To meet ISO 9001:2000 standards, the courseware design and development organization must meet the following requirements:

- Establish a courseware design and development planning process.
- Create and document procedures to control the courseware design and development process.
- Build procedures to ensure all courseware design input requirements are identified, documented, and reviewed and that all design flaws, ambiguities, contradictions, and deficiencies are resolved.
- Identify individuals routinely involved in the courseware design and development process and ensure their input is properly documented, circulated, and reviewed.
- Institute procedures to control design outputs.
- Introduce procedures that specify how product design reviews should be planned and performed.
- Develop procedures that specify how design outputs, at every stage of the courseware design and development process, should be verified.
- Establish a process that validates the newly designed courseware meets customer requirements.
- Develop procedures to ensure all courseware design modifications are documented, reviewed, and formally authorized before they are implemented.

Design and development activities can be complex and it is not always easy to keep timelines under control. While it is in no way the intent of this process to restrict creativity of the instructional designer, it is important to ensure that the design and development process is controlled. Like any other operation, the type and extent of design control should be dependent upon the complexity of the courseware to be developed and the number of people involved. In some cases, design and development plans can be as simple as a short flow-chart or checklist (as in Figures 2, Development Process Deployment Flow Chart). In complex designs, more sophisticated planning techniques are necessary.

Establish a courseware design and development planning process

The first step is to create a clear courseware design and development plan. This plan should identify standardized responsibilities and authorities and specific timelines. It should describe which groups or individuals are involved (for example: customers, subcontractors, regulatory bodies, etc.) and how. The plan should also clearly identify the stages of the design and development process, including any checks and/or verifications for each stage. It is not uncommon for conditions to change during the design and development process. A design and development plan only has value if the process is updated when these changes occur.

Create and document procedures to control the courseware design and development process

The Quality Management System (QMS) is an overall business system that implements a company's Quality Policy, establishes procedures for providing products and services that meet or exceed customer expectations, and satisfies external quality system requirements. The QMS includes policies, procedures, organizational structure, requirements and responsibilities for achieving the quality policy. Company's can best manage their operations and ensure customer satisfaction by using the following three tiers of processes:

- Management processes for corporate and division management of the QMS. These processes govern all subordinate processes.
- Product and Service Realization processes relative to the operations required for design and development products.
- Project-Specific Processes relative to requirements specific to a given project.

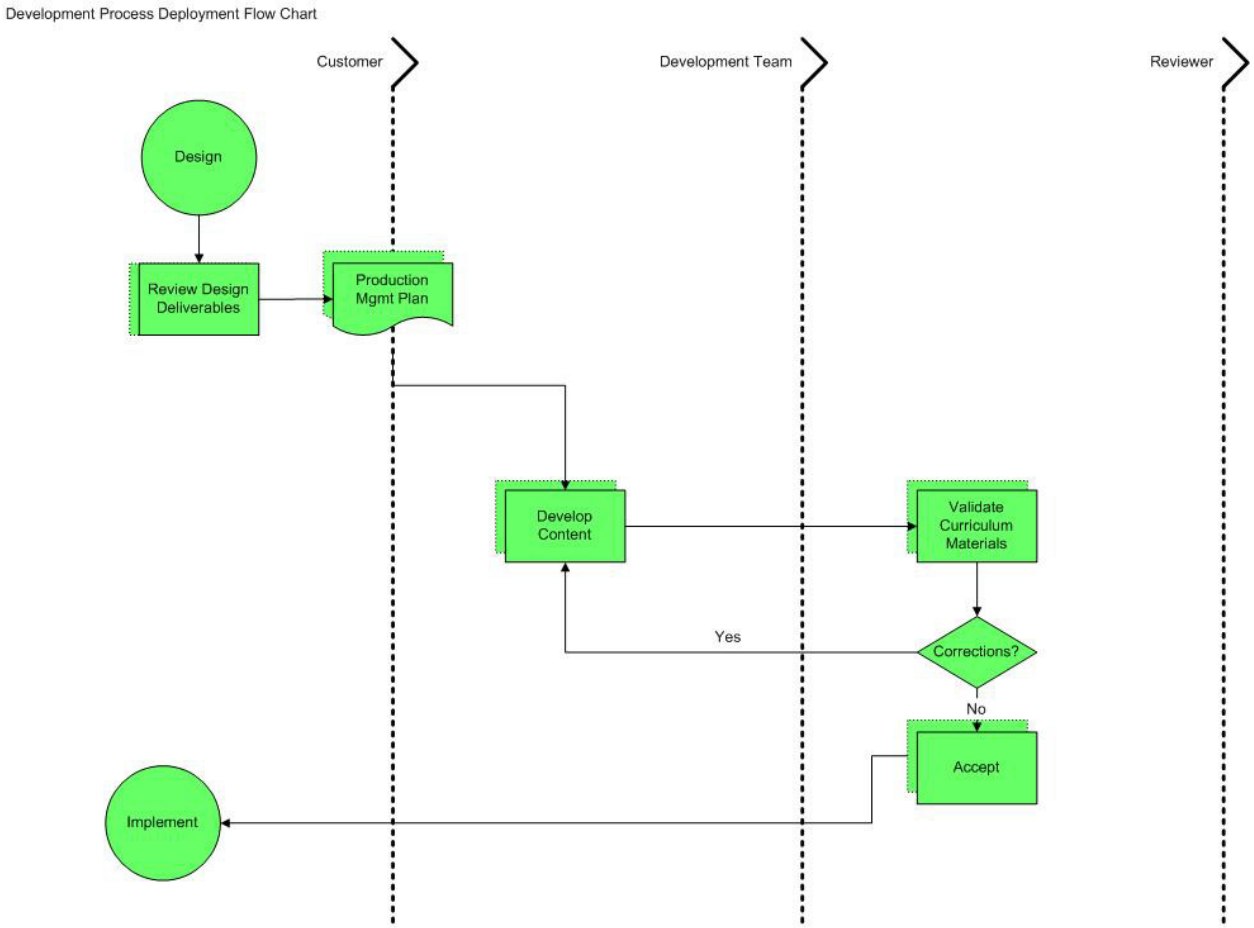

Figure 2. Development Process Deployment Flow Chart

Build procedures to ensure all courseware design input requirements are identified, documented, and reviewed and that all design flaws, ambiguities, contradictions, and deficiencies are resolved

In every courseware design and development process, it is crucial to know what is required, when, and in what sequence. Design and development inputs define all requirements that the design must meet to be successfully developed. For example, inputs from design to development would include:

- A learner analysis including levels of learning, levels of interactivity, and performance measures.
- A design package.
- A learning hierarchy analysis.
- Detailed instructional strategies.
- A media analysis.
- Detailed information about application, specifications, and required materials that would be contained in a capability solution.

Identify individuals routinely involved in the courseware design and development process and ensure their input is properly documented, circulated, and reviewed

The plan should identify individuals within the organization who are responsible for ensuring activities required by the QMS are planned, implemented, and controlled and that corrective actions are monitored. This ensures individual input is documented, circulated, and reviewed.

Institute procedures to control design outputs

The development output is a direct result of the design input. The output is a clear description of the product and contains detailed information for courseware implementation. For example, based on the customer's requirements (design input), the sailor will be able to clearly and specifically describe the process of changing an aircraft tire, including the tools required, safety precautions, and documentation requirements.

Other examples of design and development outputs include:

- An engineering design that is generally in the form of drawings and calculations.
- A graphics art design that is in the form of a particular layout to be used in a lesson.
- A finished lesson of instruction that is compatible and operational on an enterprise network (i.e., Navy/Marine Corps Intranet [NMCI]).

The format of the design and development output is obviously dependent upon the type of courseware to be produced. The design and development plan should describe what format the courseware should follow. Whatever the format, it is essential that the output meet specification requirements, that it contains clear criteria for acceptance or rejection, and that it clearly defines the characteristics of the product. If prototypes are necessary, the output plan should specify functional requirements and outline testing procedures to analyze operability, portability, and technical specification compliance.

Introduce procedures that specify how product design reviews should be planned and performed

Design and development reviews are checkpoints to determine if the courseware design and development process activities are on track. More specifically, organizations need to verify if the product adequately meets customer requirements. For simple courseware design and development activities, it may be sufficient to conduct one review at the very end of the process; however, performing only one review may be risky for more complex courseware design and development efforts. If there are any problems identified as a result of the review, it may be very costly, and in some cases, too late to go back and reconstruct design and development activities to correct the problem.

Results of reviews during the design and development processes, including any problems that are identified and their resolution, must be recorded. This may be as simple as noting on the plan that the review has been carried out, as well as any follow-up actions signed off by the reviewer and dated. More complex designs may be reviewed in a formal meeting, and the minutes of this meeting would constitute the design review record.

Thorough reviews can prevent problems in a later stage; therefore, all relevant parties should be involved. This may include internal departments, as well as customers and subcontractors.

Develop procedures that specify how design outputs, at every stage of the courseware design and development process, should be verified

Design and development process verifications confirm results meet customer requirements. If the design and development output is approved, the organization proceeds with implementation; therefore, it should be clear (in the design and development plan) who is authorized to perform the verification, how the verification is performed, and where it is recorded. In the case of web-based courseware, verification is dependant upon demonstrating it performs to technical specifications. Performance verification can be established through the use of test benches or PC work-stations configured to customer technical specifications to demonstrate operability within the environment.

Establish a process that validates the newly designed courseware meets customer requirements

After design and development verification is completed, the actual courseware is produced. Validation determines whether the actual physical product meets original input requirements. This is the final stage of design and development and is a valuable opportunity to prevent serious financial loss. Validation should be performed before delivery of the product to the customer so any problems can be corrected.

Sometimes it is impractical to perform validation before delivery of the product to the customer, as in the case of new or recently modified weapons systems. With these sorts of products, the organization should perform checks on “parts” of the final product. In most cases, performing the validation process before introducing the new product is required. If the development output is, in itself, the actual product, then development verification and validation are one and the same activity. ISO 9001:2000 requires the results of validation activities be recorded, including follow-up actions, where applicable.

Develop procedures to ensure all courseware design modifications are documented, reviewed, and formally authorized before they are implemented

As discussed earlier, equipment and weapon systems are rarely stable. Most designs are subject to frequent changes sometimes before the courseware design and development process is complete. It is as important to track changes as it is to control the original design and development process. It should be clear how these

changes are handled and what effects they have on the end product.

COURSEWARE DESIGN AND DEVELOPMENT AS A PRODUCTION LINE PROCESS

Now that we've discussed how courseware design and development can be applied to the ISO 9001:2000 model, let's take a look how a specific process is folded into the overall courseware design and development process.

As the Navy undergoes its Revolution in Training, it is redefining itself as a network-centric force. Virtually all elements of networking are represented in the capabilities of NMCI, and many of those are key enablers for the Navy's force transformation. When NMCI is complete, it will be the second-largest information technology network and provide both the Navy and Marine Corps with access, interoperability, and security for information and communications (Ackerman, 2004).

The widespread interconnectivity made possible by NMCI will also support the deployment of Navy and Marine Corps, web-based courseware applications. In order to ensure web-based courseware, developed for use on NMCI, can "play" in the environment they must now be certified according to the Department of Defense (DoD) Information Technology Security Certification and Accreditation Process (DITSCAP) (e.g., DoD Directive 5200.40 established the DITSCAP as the standard certification and accreditation process for the Department of Defense).

The objective of the DITSCAP is to establish a standard, infrastructure-centric approach that provides the proper balance between operational support capability, acceptable risk, and life cycle costs to ensure necessary informational support to fulfill the missions of all entities that rely on the Defense Information Infrastructure (DII). The DITSCAP provides a process and set of activities for all information security (including NMCI). Accreditation resulting from the DITSCAP will help ensure that benefits, risks, and costs are considered from both the local operational organization (i.e., NMCI) and the DII community perspective (DoD Instruction 8510.1, 2000).

So, how might that impact our courseware design and development process you ask? Quite simply, if the completed courseware "product" doesn't pass NMCI certification and accreditation requirements, then the courseware you may have just spent $500K to $1M on is essentially dead in the water.

Applying the ISO 9001:2000 model to the courseware design and development processes will ensure a review and compliance with DITSCAP requirements at designated points in the process. This guarantees DITSCAP requirements are accounted for in the design and development inputs, outputs, review, verification, validation, and change steps of the process and ensures they are predictable and repeatable.

CONCLUSION

The application of ISO 9001:2000 standards will enhance customer satisfaction and ensure courseware design and development products consistently meet customer and applicable regulatory requirements. This does not mean creativity is lost because the Science of Learning is embedded in the process. It also does not rob industry of their uniqueness because an ISO 9001:2000 QMS is a product of their own creation.

The goal of this standard, as applied to the courseware design and development process, is to control the process in such a way to ensure products are designed and developed in a consistent and repeatable manner and meet customer requirements – every time.

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