Enhancing Training Effectiveness Through Process Approach
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Abstract: Employers of NDT personnel have no reliable means to ensure that NDT personnel have not left out relevant flaws in the materials they were assigned to test. Confidence level in the certification of personnel is low since huge variance exists in the various trainings conducted worldwide. A critically important section like “practical exam” can be passed at 70% performance. Although examination systems ensure that only worthy students get certified, yet there are no guidelines on monitoring and measuring the learning objectives in personnel certification programs. This gap leaves much to be desired, when on field performance requirement of certified NDT personnel is more than 95%.

Non Destructive Testing (NDT) by itself is defined as a special process [1]. Same “special process” criticality was assigned to NDT training and the proven quality management concepts like ‘process approach’, ‘PDCA’ and ‘continual improvement’ were applied to solve the problem. The whole program was broken down into several short “modules” each of which is considered as an essential building block for the next one. FMEA was conducted to identify the possible sources of loss of learning (ranging from poor student attention to weakness in concept delivery by faculty).

Monitoring and measurement check points were scientifically designed to mitigate the risk of loss of learning at the end of each such module. The tool offers instant computation of measurement results by the student and the faculty. This brings out the gaps in the learning process transparently and the realization brings motivation and coherence. The Training course coordinator ensures that appropriate corrective actions are taken immediately. Students are encouraged to return a feedback on these corrective actions as a measure of their confidence level and sustained correct learning and assimilation. The whole cycle is repeated for each module.

The statistical analysis of a sample size of 2000 learners, over a 5 year period, involving five different NDT methods, reveals that students have increased levels of value learning and retention, better self-confidence at the time of final examination, better overall scores and better pass percentages in the training courses thus enhancing the overall effectiveness considerably. This systematic and scientific tool which treats “NDT Training” as a “special process” brings about standardization and more effective replication of the standardized process nearly eliminating the dependence on the personal delivery acumen of the NDT Level-III trainer. Effective delegation of modules to “NDT Instructors” becomes possible without loss of quality.

Keywords: Training standardization, Effective Education, Reliable Certification, Process Approach.

Introduction: Training is performed to add knowledge and skill value to human resource, thus, it fits into a “process” definition. A Special process is one that produces outputs, which cannot be verified before being released to the customer. So ‘Training’ is a special process [1]. Any process shall be controlled for effectiveness. Special processes are validated by controlling the inputs.
The Nondestructive Testing (NDT) personnel take training as a qualification requirement to certification. Examination at the end of the training, is analogous to ‘final inspection and testing’ of ISO 9001 QMS [2] before release of a product to the customer. All NDT examination schemes have three separate assessments – Theory, Specific and Practical. However, there are no guidelines available on monitoring and measuring the learning objectives during the training programs.

Limitation of such final examinations is the scope of coverage. It is more like ‘sampling audit’ of ISO 9001 QMS, where it is not necessary to make assessment on everything that was delivered in the training curriculum. Although a candidate is declared pass, when he scores 80%, certified NDT personnel may be expected to deliver 95% performance on field. There is a big chance that the candidate was not assessed at all on the topics he didn’t understand. This gap between requirement and actual delivery needs to be bridged!

This paper is an attempt to describe a training process model developed at Satyakiran School of NDT, Delhi, India when they obtained ISO-9001:2000 certification and got accreditation from the National Certification Board of India. This “SK process model” is presented here with performance data study of 2000 trainings over a five year period. Limited and customized trainings are excluded from this study.

The design of “SK Process Model”:
The “SK process model” is built around 5P principles, FMEA and the process approach for developing, implementing, measuring and improving the effectiveness of the NDT Trainings delivered.

A. Use of 5P’s concept:
Satyakiran School of NDT as an organisation applies the 5 P’s strategic management model [3] to align the key variables essential for improving the efficiency and effectiveness of its operations namely NDT trainings.

**Purpose:** Mission, Vision, Targets, Quality policy et.al. of the organization are laid out in their quality system documentation. The purpose of NDT training is defined as required skill enhancement whether or not followed by certification.

**Principles:** Then organization engages all the trainees in deliberations on ethics, integrity and responsibility, attached to the noble profession of NDT in a valedictory session, post formal training. The culture of the organization is of equal respect to all. An environment conducive to learning, with no interference from the outside world is ensured by providing in-house all tools, resources and even food. Incompatibilities and inconsistencies that otherwise lead to loss of time, energy and focus are avoided by advance planning and prearranged layouts, delegation of responsibility and appropriate authorization of people.

**Processes:** The ‘SK process model” is presented in this paper.

**People:** Top management, Level-III and Level-II trainers, lab instructors, coordinators and support staff meet or exceed the documented qualification requirements for their job profiles. They are motivated, coherent and have undertaken ISO-9001 QMS trainings, personality and attitudinal trainings and continually upgrade their subject knowledge. They are aligned to the organizational objectives and goals.

**Performance:** The performance metrics of importance to the trainee are presented in this paper. Other measures and results that aid in decision making for organizational administration are aligned to ISO 9001-QMS.
B. Use of FMEA Tool:

**Failure Modes and Effects Analysis (FMEA)** [4] is defined as a systematic, proactive tool used for evaluating a process, to identify where and how the process might fail. It is also used to assess the relative impact of different failures. This tool was used to identify those inputs in the NDT training process, which need to be controlled. The purpose of this exercise was to build a framework of measurable parameters in the training process. Aim was to objectively initiate corrective and preventive actions well in time and continually improve the trainings.

For the case in study, the failure modes were identified in detail but the effects analysis was dropped in favor of a simplified consolidated effect i.e.- loss of training effectiveness.

Thirteen potential reasons were identified that could contribute to effectiveness loss. These were grouped into *Flexible* and *Rigid* based on the nature of the cause. *Flexible* are those which can be altered during the training by initiating corrective or preventive actions whilst *Rigid* cannot be worked upon significantly during any training. Flexible reasons were attributed to the two main affected parties i.e. the trainee and the trainer.

**Type I – Flexible modes that create an effect on training performance**

a. Poor student attention
   i) Personal reasons of trainee
   ii) Training environment
   iii) Role play definition and adjustment

b. Low Faculty performance
   i) Personal Reasons of trainer
   ii) Competence
   iii) Time mismanagement
   iv) Incomplete Delivery
   v) Asynchronous Delivery

**Type II - Rigid modes that create an effect on training performance**

c. Heterogeneous batch
   i) Basic Education Level differences
   ii) Communication differences
   iii) Cultural differences

d. Erroneous Input (Not consistent with declaration/documents)
   i) Input Level of knowledge of trainee
   ii) Experience of student

C. Use of the PDCA Tool:

The **Plan-Do-Check-Act (PDCA)** is an established methodology which provides a framework for establishing, implementing, monitoring, measuring and continually improving the process performances to ensure that both stated and implied needs of the customer are met with.

**PLAN:**

Each training plan conforms to the applicable personnel certification standard like IS-13805 or SNT-TC-1A or CP-189. Yet, the complete training curriculum is redesigned into equally balanced *modules*, which act like a step ladder. This makes intermediate assessments (akin to in process inspection of ISO 9001) possible and arrests any loss of
learning, well in time. The key feature of a “module” is synchronous mapping of theory and practical. The theory in the module is no less or more than the practical session coverage. This is planned to enhance effectiveness.

End of module assessments are planned to obtain data on the eight flexible process control parameters. Data analysis inputs and outputs are planned to aid decision making on corrective actions.

Sector specific requirements for each student like industry standards to be used in training and defect samples/equipments/consumables to be used in practices are planned before start of delivery.

Expected output of practice sessions are prerecorded as “standard result sheets” validated by Level-III subject experts.

All training plans are documented.

**DO:**

Trainees are provided with complete course kit and other tools and resources before start of training.

Trainings are conducted as planned and actual execution data for each module recorded in daily log sheets that capture information on parameters like the name of trainers, the topics covered, start and stop times, student attendance, worksheets, end of practice module reports, etc.

A consolidation refresher of the whole program is given after completing all the modules, followed by a mock test on the lines of final exam.

Changes if any to the planned arrangements are approved by authority prior to implementation and all concerned, informed accordingly.

All process records are preserved in a well designed records archive by training manager/officer.

Five Key Performance Indicators (KPI) are measured from this data:-

- Time mismanagement, Incomplete Delivery, Asynchronous Delivery, Personal reasons of trainee and Personal reasons of trainer.

**CHECK:**

Checks for monitoring training delivery are performed at multiple levels, viz:

1. Entry level
2. End of module quiz
3. Trainee feedback on end of module corrective actions
4. Midway Trainee feedback on the training program and facility
5. Mock test at the end of consolidation refresher

Trainees are subjected to an entry level examination before the commencement of training. The exam results enable the trainer to fine tune with the trainee. This is analogous to “incoming inspection” of ISO9001.

The training delivery of each module in both theory and practical is monitored for effectiveness. This is done by subjecting the trainee to an end of module quiz that covers all the contents of the module. This is analogous to “in process inspection”

The quiz results data is processed and analyzed to generate information on

(i) Whether the faculty has failed to deliver a concept effectively
(ii) Whether the faculty lacks competence to deliver the particular concept
(iii) Whether the design of quiz is faulty
(iv) Whether the trainee in particular comes with a poor input knowledge base
(v) Whether the trainee in particular comes with a poor experience

The data analysis is quick. Excel sheets are programmed to compute and provide the analysis output. Standard result sheets are used to compare the practice module reports of trainees.

Trainee feedback at the end of module and corrective actions generate information on an important KPI - trainer competence

Midway Trainee feedback generates information on two KPIs – Training environment and role play/adjustment (sometimes also on cultural differences)

Mock test and final feedback generate information on the value learning and retention of the training along with trainee self confidence.

ACT:
Corrective actions are initiated and completed before commencement of the next module. The nature and extent of corrective actions, depend on the outcome of end of module data analysis.
Corrective actions include but are not limited to
  1. Faculty counsels each trainee for wrong attempts
  2. Retraining sections/topics not understood by class
  3. Upgrading skill/competence of faculty by his seniors
  4. Retraining/Discussion by a different senior faculty
  5. Extra time to individual weak trainees for reducing gap
  6. Use of translations for bridging communication gap
  7. Modification to planned arrangements when necessary
  8. Counseling trainees with role play/adjustments issues
  9. Improvements/changes in training environment/food/resources
  10. Improvements/changes in speed, modulation, fine tuning of trainer

The study:
The study presented here was conducted to assess the effect of process approach on training effectiveness at Satyakiran school of NDT. The data covers 400 trainee samples, each from five (Ultrasonic testing, Radiographic Testing, Magnetic Particle Testing, Liquid Penetrant Testing and Eddy Current Testing) certification programs including at Level-I and at Level-II, totaling 2000 cases in a time span of five years.

The data was analyzed to measure:
  a. Increase in Value Learning and retention
  b. Increase in Self Confidence
  c. Increase in Overall Scores
  d. Increase in Pass percentage of the Batch

Results:
  a) Increase in value learning and retention
b) Increase in self Confidence

No. of Doubts

- Avg Module 2%
- mock test %

No. of Doubts
c) **Increase in overall scores**

![Graph showing overall scores per percentage range](image)

- **70%-80%**
- **80%-90%**
- **90%-100%**

- 2 per. Mov. Avg. (70%-80%)
- 2 per. Mov. Avg. (80%-90%)
- 2 per. Mov. Avg. (90%-100%)

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d) **Increase in pass percentage**

![Graph showing No. of Failures](image)

**No. of Failures**

- **No. of Failures**
- 2 per. Mov. Avg. (No. of Failures)

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**Discussion:**

a. **Increase in value learning and retention**

Module 2 of each course was selected to study the value learning and retention. Module 1 is generally very simple and covers basics that come from previous learning of the
trainee. New value learning begins from module 2. This is also the most difficult to retain till the end of training especially in a crash course where self study opportunity is minimal. The %score in module 2 was compared to the %score in similar questions content of mock tests. It is observed that the gap in retention has reduced from about 10% to about 2%.

b. Increase in Self Confidence
After the completion of all the modules, the trainees are subjected to a consolidation refresher of the overall program, followed by a mock test. Students are encouraged to clear all their doubts in an interactive freewheeling session often involving several faculty members. The total number of doubts raised by the students after the refresher was considered to be a measure of lack of self confidence of the trainees. This data was collected post facto through interviews with faculty in round figures. For a more scientific assessment, this data collection should be formally planned and recorded in real time. As stated by the faculty members, the doubts raised by trainees have reduced from around 60 per month to around 12 per month. This is an indicator of the increase in self-confidence and effective training.

c. Increase in overall Scores
The results of the final exam were evaluated for the sample batches in groups of 200 trainees. Number of trainees passing the exam with a score between (80% - 90%) was studied. There is a definite trend of more trainees passing out in (80%-90%) bracket than (70%-80%) bracket earlier. However, there is no significant growth in the number of trainees scoring in (90%-100%) bracket.

d. Increase in Pass percentage of the Batch
The number of students failing any section of the exam has fallen from 15 per 200 to 11 per 200 indicative of increase in pass percentage of the batches.

Conclusion:
Systematic process approach to NDT Training, continual improvement in elemental steps during the training delivery itself on pre identified, measurable inputs have proved successful in enhancing the training effectiveness at Satyakiran School of Non Destructive Testing, Delhi, India.

References
[3] 5P Model,
[4] Institute for Healthcare Improvement, Cambridge, Massachusetts, USA, FMEA tool