

Guiding Principles for an Effective TNA for Simulation

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Abstract. Training Needs Analysis (TNA) processes for simulation should be appropriate to the circumstances of each project. What is effective for one weapon platform may be quite inappropriate for another. Consequently, rigid procedures for TNAs are not valid and would invariably lead to less than optimal outcomes. However, this paper argues that certain guiding principles can be defined for the planning of TNAs for simulation. These principles address key components of: a framework for instructional design, identification of training tasks, specification of instructional functions, modelling of training task requirements and learning environment capabilities, and development of cost-benefit metrics.

This paper briefly discusses the basis for the proposed guiding principles and provides illustrations from recent ADF simulation studies. The perspective of TNA adopted in the paper is one of instructional design as distinct from engineering specification.

1. INTRODUCTION

This paper examines processes for analyzing training needs when simulation is a likely, or pre-determined, instructional method. Accordingly, discussion in this paper assumes that the purpose of Training Needs Analysis (TNA) is to provide detailed information regarding instructional functions that should be sought through simulation.

The starting point for TNA, for the purpose of this paper, is defined to be upon completion of a job analysis and the statement of associated competencies. Where applicable, a competency gap analysis would normally be considered to be a part of the TNA process, but this is also assumed to have been completed so that the following discussion may focus on issues related to simulation capability.

In order to define instructional functions that should be sought through simulation, the TNA process must identify the scope of training under consideration, define the required functionality of learning environments and provide a means for comparing candidate solutions. In practice, application of this process requires the following key components:

- Adoption of a skills learning model that may be used to identify training tasks.
- Identification of a comprehensive set of training tasks.
- Specification of classes of instructional functions applicable to identified training tasks.
- Modelling of training task requirements and candidate learning environment capabilities in terms of specified instructional functions.
- Development and application of cost-benefit metrics to modelled future training system options.

The following discussion of these key components of an effective TNA process draws on techniques and tools employed during studies for several ADF aerospace simulation projects. These methods do not constitute the only suitable approaches and other techniques and tools may be equally effective in implementing the listed key components. Nonetheless, consideration of past successful approaches may assist in framing guidance for the planning of future studies. To help achieve this end, suggested principles for the planning of TNA processes are presented next to their respective justification in the following discussion.

2. A FRAMEWORK FOR INSTRUCTIONAL DESIGN

The first key component of an effective TNA process has been defined above as adoption of a skills learning model which may be used to identify training tasks. This step is often overlooked in training system development projects because of a misconception that competencies constitute the learning activities to be undertaken in training. Statements of competency, competency elements, performance criteria and skill variables are frequently directly transcribed into statements of training activities. There should be no misunderstanding that competencies define the desired outcome, and not the process, of training.

Given that the end-point of training is defined by competency statements, a skills learning model may be used to determine a comprehensive and coherent set of training activities (or tasks) which will culminate in student attainment of the desired skill sets. A suitable skills learning model must encompass all stages of skill acquisition for which simulation may be considered and be consistent with ADF training policy and practices.

TNA Principle 1: *A documented skills learning model should explain progression from entry to training to completion of a categorization and proficiency scheme.*

The skills learning model employed by Learning Systems Analysis P/L is that of Incremental Transfer Learning. This model was developed through an ADF Defence Force Fellowship in 1990 [1] and argues that the acquisition of a skill may be viewed as an evolutionary process extending over definable stages. During this process, learners transfer their skills between increasingly complex environments; this is referred to as incremental transfer.

A major benefit of the incremental transfer skills learning model is the availability of general instructional strategies to support transfer. Consequently, application of the model to competencies for a specific skill qualification produces a coherent and comprehensive set of training tasks.

TNA Principle 2: *The documented skills learning model should explain the types of instructional activities that should occur throughout the training program.*

A further advantage of a documented skills learning model is that instructional practices peculiar to certain skill domains, such as Maritime or Air Defence operations, may be formally incorporated. This tailoring of a skills learning model to a certain domain produces a detailed training concept that may be used to provide justification for the design of suitable learning environments, eg simulations.

TNA Principle 3: *A formal training concept should explain how the selected skills learning model is applied to the context of training.*

The framework for instructional design needs to permit iterative application of the skill learning model. The concept of working at macro, mid and micro levels of training system development may be usefully applied here. During the early stages of a simulator acquisition project training analysis is conducted at the macro level with the aim of defining the general instructional functions to be provided. Once the types of training devices have been selected and operational system interfaces and procedures are known training analysis at the mid-level may be used to define requirements for specific stimuli and instructional support features and conduct trade-off analyses. Finally, once the final design of training devices has been determined and curricula established training analysis at the micro level may be used to develop scenarios and lesson plans.

TNA Principle 4: *Processes for the definition of general instructional functions, stimuli, instructional support features, scenarios and lesson plans should be documented.*

3. IDENTIFICATION OF TRAINING TASKS

Training tasks are statements of the activities to be undertaken in order to achieve, demonstrate and maintain required competencies. As such they may be derived by application of the selected skills learning model to defined competencies. Training task lists that are produced through Logistical Support Analysis Task

401 do not apply a skills learning model and focus on the operation of systems rather than their tactical employment. Consequently, the output of such Logistical Support Analysis activities should not be considered adequate for the identification of training tasks.

TNA Principle 5: *The TNA process should develop statements of training tasks, as distinct from competencies, competency elements, performance criteria and learning objectives.*

Training tasks used to demonstrate, and thereby certify, safe and effective workplace performance may be transcribed directly from the performance criteria and skill variables defined during job analysis.

TNA Principle 6: *Training tasks intended to certify safe and effective workplace performance should encompass performance criteria and skill variables defined during job analysis.*

Training tasks that demonstrate safe and effective workplace performance require availability of a sufficient range of skill variables for there to be confidence in the skill assessment. A training task that only requires performance to be demonstrated under a very limited set of operational circumstances would not generally be adequate to confidently state that performance at the stage of Skilled had been demonstrated. Consequently, definition of an appropriate range of skill variables is important for training tasks used to test competence. If not formally stated as part of each training task, skill variables can be defined later in the TNA process through requirements for stimuli and instructional support features to support training.

TNA Principle 7: *The TNA process should determine the full range of variables associated with each training task.*

Training tasks used to maintain required competencies, such as those forming a categorization and proficiency scheme, need to reflect the performance standards and range of skill variables of training tasks used to demonstrate competence during initial training. A fundamental difference that may exist between these two types of training tasks stems from demonstration of competence focussing on individual performance while maintaining competence focusses on team and collective performance. Consequently, training tasks aimed at maintaining competence may specifically require tasks to be performed as part of a team and during a larger collective training activity.

TNA Principle 8: *The TNA should examine requirements for training tasks that address team and collective training.*

Any analysis of required simulation functionality should pay special attention to those training tasks that cannot be safely or effectively performed in the live operational environment. Restrictions on use of the live

environment can stem from limited availability of resources, risk management, and political considerations. In such cases, the live environment can generally be used in some constrained manner to provide part-task training, but whole-task practice is, by definition, not available.

TNA Principle 9: *The TNA should identify training tasks that cannot be wholly conducted in live training environments.*

With training tasks for demonstration and maintenance of competence established, work may commence on the derivation of preceding training tasks, i.e. those that lead from entry to a training program to graduation. The number and range of preceding training tasks will be dependent on the difficulty of the skills being developed and the range of variables under which they must be successfully performed.

TNA Principle 10: *The TNA should include processes for identification of 'preceding' training tasks that lead from entry to training up to certification of competence.*

Application of a robust skills learning model should ensure that preceding training tasks are more than simplified versions of those training tasks that test competence. While exposure to simplified contexts for skill performance is an important developmental strategy, consideration should also be given to other instructional issues such as required level of stimuli fidelity and the way intervention in task performance should vary with stage of learning. These issues have important implications for required features of learning environments and may substantially influence design decisions.

TNA Principle 11: *The TNA, training concept or skills learning model should provide strategies to guide how training tasks and associated fidelity and instructional support features vary as skill development progresses.*

An example of the way fidelity may vary with stage of skill progression may be drawn from a recent study of Command Teams within an Air Defence Regional Operations Centre. [3] Three broad classifications for stimulus fidelity were defined: Authentic, Representative, and Abstracted. Application of a skills learning model to the context led to a general rule that stimuli associated with Skilled level training tasks should be Authentic, while stimuli associated with Prepared level training tasks should be Representative. Other rules were formulated for training tasks at the stage of Trained and for the fidelity classification of Abstracted. This approach led to identification of some training tasks that were most appropriately performed in the abstracted environment of a Tactical Floor exercise. Omission of the Abstracted fidelity classification would almost certainly have maintained attention on the operational environment and limited the study outcomes.

The above discussion has addressed the need for identification of training tasks to achieve, demonstrate

and maintain required competencies. A logical extension, and nexus with actual operations, is that of mission rehearsal. If training is the process of preparing for operational performance, then mission rehearsal must be a final aspect. Moreover, learning environments may provide valuable venues for the conduct of mission rehearsal and, therefore, this application should be considered in their design.

Unlike other training tasks, those identified for mission rehearsal need to cater for unknown future operational circumstances. For example, mission rehearsal training tasks should permit variation in environmental circumstances, such as region, as well as operational circumstances, such as opposing force weapon systems and tactics. The identification of mission rehearsal training tasks provides a documented basis for the design of suitable training environments and the development of tools and procedures to support future scenario planning. Without a clear statement of such tasks these two important precursors to mission rehearsal planning would have no clear basis.

TNA Principle 12: *The TNA process should include consideration of mission rehearsal and the requirements of associated learning environments.*

4. SPECIFICATION OF INSTRUCTIONAL FUNCTIONS

The instructional functionality to be provided through simulation should be determined by aggregating the functions required by each identified training task. This is not to suggest that simulation should provide all of these functions; that is an issue for subsequent cost-benefit analysis. However, simulation should initially be considered a candidate learning environment for all training tasks and a thorough examination of instructional functions should be undertaken.

TNA Principle 13: *The TNA should define the scope of instructional functions to be considered for simulation.*

In the case of a flight simulator required to comply with ICAO and CASA qualification requirements, stimuli fidelity and instructional support features are already well defined. Use of the Manual of Criteria for the Qualification of Flight Simulators (MCQFS) for a flight simulator provides clear and measurable standards of both stimuli and instructional support features. Nonetheless, unique military flight crew training tasks should still be investigated to determine specific instructional function requirements.

Given that flight simulator functionality will already be described in the terms defined by the MCQFS, these same terms should be used, where appropriate, to define required functionality for unique military training tasks. An example of this approach may be drawn from a Training Task Analysis Study conducted for the RAN's Seaking Helicopter Simulator. [4] In this case, the FAA Helicopter Simulator Qualification document AC 120-63 was used as the basis for defining device

functionality. One function defined by AC 120-63 is Runway Visual Range (RVR) with varying levels of device having different RVR values. Unique military Sea King pilot training tasks were surveyed for required RVR permitting civilian standards to be applied to military requirements.

Stimuli for flight crew training tasks, other than those that are considered to be adequately addressed under the MCQFS, should be described in terms of the cue generator (i.e. a specific cockpit instrument or functional grouping of related instruments), the mode of sensation (eg visual, aural, vestibular, haptic and proprioceptive) and the required fidelity. Definition of required fidelity can be problematic and is possibly the greatest single benefit of international standards such as those provided by the MCQFS. Fidelity analysis at too fine a grain-size can make a study impracticable with enormous amounts of data required for each training task. On the other hand, a coarse grain-size analysis may provide results that are meaningless to the engineers who must translate them into technical solutions. Consequently, a balance is required when defining levels of fidelity for a TNA study.

Similarly, stimuli for non-pilot mission crew should also be described in terms of the cue generator (eg a radar display), the mode of sensation (eg visual) and the required fidelity. Precisely the same issue of fidelity analysis as that for flight crew applies to mission crew. Unlike pilot training, an applicable standard does not exist for specification of mission crew simulation. Consequently, a major analysis effort will be required to assess the requirements of each identified training task in terms of specified instructional functions.

In summary, details of instructional functions to be investigated for each training task need to be defined in advance of the assessment of each training task's requirements and should be agreed to be adequate for the purpose of establishing detailed simulation functionality.

TNA Principle 14: *The TNA should provide a strategy for the definition of stimulus fidelity.*

A comprehensive set of instructional support features should be defined prior to the analysis of training tasks. These features must support the eventual instructional processes and, therefore, some form of functional job analysis regarding instruction is required. Such an analysis would typically identify all staff positions, the instructional and instructional support tasks to be performed and associated techniques, including use of instructional support features.

TNA Principle 15: *The TNA should include a functional job analysis, of instructional and instructional support staff, to define a comprehensive set of potential instructional support features.*

5. MODELLING OF TRAINING TASK REQUIREMENTS AND LEARNING ENVIRONMENT CAPABILITIES

Training tasks should now be investigated in terms of specified instructional functions. The aim should be to define the stimuli and instructional support features required of a suitable learning environment. Some required instructional functions will be immediately apparent, such as a visual model of a Tanker aircraft for flight crew Air-to-Air Refueling (AAR) training tasks. Other training task requirements will be dependent upon the skill learning model, and associated training concept, being employed.

TNA Principle 16: *The TNA should investigate each training task for required instructional functions.*

For example, the incremental transfer skills learning model requires the full range of skill variables for normal contexts of task performance to be available for training tasks in late stages of transfer. So, for an AAR training task at the Skilled level visual models for all Tanker aircraft types, for which the student is to be certified as competent, should be available. As mentioned earlier, application of a suitable skills learning model should have resulted in a detailed training concept addressing issues such as the range of variables required at each stage of skill progression.

In practice, training tasks in late stages of transfer tend to combine a number of component skills into a logical block, eg AAR training would be a component of a larger mission; this is the sort of information that should be available from a detailed training concept. Nonetheless, students would need to have the opportunity to practice task performance with all Tanker types for which they are to be certified as competent.

The practice of defining required instructional functions on the basis of a skills learning model and associated training concept means that training task requirements are being modelled. Similarly, the capabilities of candidate learning environments may be modelled. The same types of stimuli and instructional support features used to model training task requirements may be used to build models of potential learning environments.

Operational equipment and any pre-selected training devices provide the most obvious starting point for the modelling of learning environments. The anticipated capabilities of operational equipment, such as an aircraft, are generally established early in an acquisition project and availability of stimuli and instructional support features may be readily documented. This model of operational equipment as a learning environment may then be compared with training task requirements and the range of training tasks that can be supported quickly determined.

In the case of simulation devices, the aim is to determine stimuli and instructional support features through the TNA process. The normal technique employed by Learning Systems Analysis P/L for this purpose is to

initially build a very simple model of such a learning environment and then add stimuli and instructional support features as enhancements until the requirements of all training tasks are satisfied. Intuitively, the simple models of a simulation device would not support sufficient training tasks to justify acquisition and models that are fully capable would be too expensive. This issue of cost-benefits is addressed in the next section of this paper. The point here is that a methodology for establishing and comparing training task requirements with learning environment capabilities has been established and may be employed to determine simulation functional specifications.

TNA Principle 17: *The TNA should model both training tasks and candidate learning environments in terms of the same instructional functions so that comparisons of training effectiveness may be made.*

Training task analysis studies employing the methodology described here may involve a large number of training tasks and a large set of stimuli and instructional support feature data. Consequently, data processing tools may prove worthwhile in order to automate much of the process. A proprietary training system modelling tool developed by Learning Systems Analysis P/L for this purpose is Tandem DSS™ (Training ANalysis and Device EMPloyment Decision Support System). As evidence of the large amounts of information involved in a thorough training task analysis, modelling a single training system option using Tandem DSS™ typically involves 30Mb to 140Mb of data.

6. DEVELOPMENT OF COST-BENEFIT METRICS

In addition to detailed task analysis information described above, measures of cost-benefits are needed in order to select a preferred training system configuration. Cost measures should include acquisition and operating costs of training devices and weapon systems that may be used for training. Benefit measures should include assessments of training effectiveness such as the extent to which learning environments are expected to satisfy training task requirements. The development of cost-benefit measures should also take account of practical issues such as limitation of training tasks under consideration to those that may have differences in cost or benefit between training system options.

TNA Principle 18: *The TNA should provide a rational and thorough methodology for cost-benefit analysis of training system options.*

Cost information should be considered for all training system options under consideration with a typical output being the annual projected cost of training under each option. Summary cost information should then be combined with training effectiveness measures to provide cost-benefit information for each training system option.

7. TNA DELIVERABLES

While the circumstances of each project will determine the precise nature of TNA deliverables, some typical products are worthy of consideration. A report on the context of the training program provides an agreed starting point for detailed analysis. A report on the analysis of training tasks and a summary of data gathered allows raw information to be reviewed prior to consideration of potential training solutions. A report on options for the provision of required instructional functions and associated cost-benefits permits debate of which solution path is preferred. Finally, a report specifying required instructional functions, under the preferred option, and an overarching concept for the development, implementation and evaluation of training is required for suitable technical solutions to be sourced.

TNA Principle 19: *The TNA should provide reports on: the training context, training task analysis data, baseline training system functions and candidate solutions, and the preferred approach.*

8. CONCLUSION

Good instructional design requires creativity and insight as well as a solid understanding of theories of learning and instruction. As such, instructional design is an art as much as a science and the same may be said for analysis of training needs. This is especially true for instructional applications of simulation where workplaces and tasks may be contrived without boundaries set by the real world. However, that part of analysis and design that is science provides guidelines that may be judiciously applied to training projects.

This paper has argued that an effective TNA process must identify the scope of training under consideration, define the required functionality of learning environments and provide a means for comparing candidate solutions. Nineteen guiding principles for the planning of a TNA for simulation have been proposed. These principles may also be useful for evaluating the strengths and weaknesses of proposed TNA processes.

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