

Training Effectiveness Readiness Levels (TERLs)

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Roberto K. Champney
Design Interactive Inc., USA

Kay M. Stanney
Design Interactive Inc., USA

Jonathan Martin
Design Interactive Inc., USA

INTRODUCTION

Training expenditures are cyclical in nature and follow general patterns in the economy, yet the use and adoption of training technologies in general has been reaching new heights, accounting for over \$1.5 billion globally in 2012 (Ambient Insight, 2013). At the same time, other domains (e.g., medicine, ground military forces) which traditionally had not benefited from simulation training have increased their use of simulation-based training. This has been, in particular, a reaction to emerging challenges such as economic pressures and reduction in resources that demand greater flexibility and efficiencies from training technology (e.g., Bell, Kanar, & Kozlowski, 2008). Simulation technologies have presented themselves as capable means to address the flexibility and experiential learning needs of such emerging training challenges (Bell & Kozlowski, 2007). While the adoption of different types of training technologies continues to increase, a major challenge faced by any organization aiming to invest in a training program is the limited ability to quantify the benefits of such training (e.g., Government Accountability Office, 2013). Assessment of a training system is paramount given that the value added by such a system lies in its ability to produce learning that an individual can then utilize in an operational environment. Without such assessment, the value or risks of training are unknown; in the same manner in which a system promises positive training results it may unknowingly produce negative training results which could be catastrophic once a trainee returns to the operational environment. Unfortunately assessing and quantifying the impact of

any training is not trivial due to a variety of challenges that range from technical (e.g., variety of theories, limited skillsets in evaluation methodology) to logistical (e.g., lack of support from stakeholders, cost and complexity of evaluations) (Phillips, 2010). Often for these reasons training assessment is relegated as either an afterthought or conducted with the least resource consuming methods (Champney et al., 2008; Carnevale & Shultz, 1990; Eseryel, 2002; Bassi & van Buren, 1999; Thompson, Koon, Woodwell, & Beauvais, 2002). In addition, given the nature of the training construct under evaluation (i.e., something that is learned, that is retained and applied later in an operational environment; Pennington, Nicolich, & Rahm, 1995; Thorndike & Woodworth, 1901) it is possible to assess different elements of training effectiveness, such as students' reactions, learning, transferred behaviors, or resulting impact on the organization (Kirkpatrick & Kirkpatrick, 2007); all of which may be labeled as training effectiveness evaluation (TEE). In some instances a system's technical or functional capabilities are utilized as proof of its training adequacy or effectiveness. This results in systems that are evaluated using a wide range of methods and levels of scrutiny, such that results are not comparable across systems nor meaningful unless one understands the method and criteria used to conduct the evaluation.

In order to address this challenge it is necessary to have a framework that objectively defines the parameters that govern the level of scrutiny and validity of different approaches to assess training effectiveness. The Training Effectiveness Readiness Levels (TERL) scale seeks to address this by providing a framework

that defines a progressive scale of training assessment scrutiny. A key characteristic of the TERL scale is its independence from technology development. The scale enables the determination of how well a system can meet training needs regardless of a training system's technological maturity. A system with a higher TERL rating implies that it has been evaluated and demonstrated to satisfy a training need using a higher degree of scrutiny than one with a lower TERL rating.

BACKGROUND

Readiness Level Scales

The use of Readiness Level (RL) scales is not a new concept. There are multiple kinds currently in use that justify this approach. These RL scales have proven to help demonstrate the maturity of scientific research, products and ideas to consumers, sponsors, and industry as a whole. Groups using unique RL systems include NASA (Mankins, 1995), the Department of Defense (2010), and the Federal Aviation Administration (FAA; Krois & Rehmann, 2005). Each RL role has specific definitions relevant to the unique needs of their respective fields but they are all based on NASA's Technology Readiness Level (TRL) scale and are modifications of those stages. NASA TRLs (see Table 1) can be described as being a systematic measurement system to assess a technology's maturity and to serve as a point of comparison between the maturities of different types of technology (Mankins, 1995).

Other groups have modified NASA's TRL scale to address their individual needs. For instance, the FAA's TRLs provide a model for research, development, and implementation of flight technology that defines a phased approach outlining what is required of both Research and Development (R&D) organizations and the FAA (Krois & Rehmann, 2005, c.f. Free Flight Research Program Plan [FAA, 2000] and Air Traffic Management Research and Technology Development [FAA, 2002]). Outside of the more technology focused area, other approaches have taken the RL concept to address specific issues such as Human Factors (HF). The need for this extension beyond technology centric maturity stems from the fact that while a technology may have matured within a TRL scale it may still prove to be incomplete or lacking maturity along a differ-

Table 1. NASA technology readiness levels (Mankins, 1995)

TRL	Description
9	Actual system "flight proven" through successful mission operations.
8	Actual system completed and "flight qualified" through test and demonstration (ground or space).
7	System prototype demonstration in a space environment.
6	System/subsystem model or prototype demonstration in a relevant environment (ground or space).
5	Component and/or breadboard validation in relevant environment.
4	Component and/or breadboard validation in laboratory environment.
3	Analytical and experimental critical function and/or characteristic proof-of-concept.
2	Technology concept and/or application formulated.
1	Basic principles observed and reported.

ent dimension. In terms of HF, this would imply that the technology lacks integration refinement with its intended human users (e.g., unusable by its intended human operator). The Human Factor Readiness Level scale (HFRL) (Hale, Fuchs, Carpenter, & Stanney, 2011) provides a means to standardize HF readiness assessment that can be used by decision makers in a wide range of positions. The HFRLs (see Table 2) are measured with respect to 24 HF study areas identified in Krois and Rehmann (2005) and the HFRL stages are based on a modified aggregate of several other TRL systems.

Using a similar approach as HFRLs, the TERL scale focuses on identifying the training maturity of a training system by utilizing the level of scrutiny utilized to assess its training efficacy. In order to understand the makeup of the TERL scale it is necessary to review the elements that impact the training effectiveness of training simulation technology and training in general. These are discussed next.

Simulation Training Considerations

Simulations, in general terms, are representations of an environment which may be real or fictional for the purposes of recreating an experience (Bell, Kanar, & Kozlowski, 2008). Simulation training systems derive

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