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Research Report

How do Submarine Force trainers use computer-based navigation trainer systems? Applying cluster analysis to examine situated objectives in the employment of adaptive CBT

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ABSTRACT

A "jobs-to-be-done" analysis was conducted to inform training and assessment techniques in support of an Office of Naval Research funded project involving U.S. submarine navigation training. In order to maximize the return on investment in training expenditures, a jobs-to-be-done analysis ensures that the transition of technologies supports critical organizational needs and objectives, particularly when the utilization of a single technology is employed to achieve various goals. The current study investigated the jobs-to-be-done by the navigation trainer across various organizational stakeholders, using data from 481 training events representing every recorded navigation trainer use in the U.S. Submarine Force during a typical training month. Each of the training activity clusters (Schoolhouse, Commander, Responsive, Staff training) revealed a specific organizational context and utilization goal. These clusters illustrate the repurposing of the same technology tool across different user groups, in order to accomplish the various purposes or jobs required by the fleet, including learning, practice, and assessment; the cluster analysis provided a rich description of how the trainer was being used in each job context. This jobs-to-be-done analysis identifies how stakeholders are using already-deployed technologies and capabilities across a variety of situated contexts, and informs best practices for versatile use of CBT technology tools.

1. Introduction

Investing in human capital by increasing the knowledge, skills, and abilities (KSAs) of human operators provides a competitive advantage in any organization. In a military context, this advantage can be critical to mission success and the minimization of casualties. KSAs can be developed via education, training, and experience (Earp, Ott, Popescu, Romero, & Usart, 2014), and leveraged to improve operational performance (Becker & Huselid, 1998; Combs, Liu, Hall, & Ketchen, 2006), but only if the training aligns with the needs of the organization. In 2011, one of the authors became the principal investigator of an Office of Naval Research funded project to develop adaptive training tools for U.S. submarine navigation training. To achieve this aim, a "jobs-to-be-done" analysis was performed to inform training techniques and content. This is particularly important in the case of computer-based training tools, where adjustments to content cannot be made "on the fly" by a human instructor in response to evolving trainee needs. The extension of a jobs-to-be-done analysis beyond the traditional gap analysis better guides training expenditures in a fiscally austere Navy budget environment and ensures that the transition of new technologies support critical training needs and objectives. In order to maximize return on investment, training must fulfill overarching goals rather than just promote task proficiency. In line with the more holistic perspective championed by Christensen and Raynor (2003), jobs should be considered as representing fundamental goals. As such, training should be designed to support more effective achievement of goals and objectives, rather than designed to teach operators how to perform a particular behavior (*e.g.*, complete a task). A goal can be achieved via a series of tasks that consist of behaviors, but these tasks occur in a situated context that involves constraints, conditions, and options for performance.

1.1. Computer-based instruction (CBI) and computer-based training (CBT)

Computer-based instruction (CBI) and technology driven training is supplanting traditional instructor-led classroom instruction due to increased cost effectiveness and performance improvement. Mottl (2000) asserts that CBI and CBT carry approximately half the

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cost of classroom instruction, a factor likely driving the increase in technology driven training and corresponding decrease in instructor-led training (Thompson & Wellins, 2003). Serge, Priest, Durlach, and Johnson (2013) note that CBT such as simulators or virtual environments also require fewer resources than live training. The trend toward increased implementation of CBT is supported by research that proposes the benefits of CBT to include reduced learning time (Maul & Spotts, 1993), increased learning retention rates (Williams & Zahed, 1996), reduced costs for training delivery (Lawson, 1999), and a greater return on investment (Allen, 1996). Because CBT is a learner-centered instructional environment that can incorporate a variety of media such as video, audio, and interactive testing, an individual's attention may be better captured, increasing motivation to attend to the training material. The capability to present information across a variety of channels or media also accommodates a greater range of cognitive styles. Cognitive style is a generally stable preference or strategy for perceiving, remembering, thinking, and problem solving, and impacts how an individual acquires, perceives, and processes information in an interactive interface (Culley & Madhavan, 2013).

Further, CBT supports adaptive training, which involves tailored training based on individual differences to support the achievement of performance standards (Schaefer & Dyer, 2012). The Office of Naval Research Capable Manpower Program, CMP-FY10-02 Adaptive Training to Enhance Individual and Team Learning has defined adaptive training as "...training interventions whose content can be tailored to an individual learner's aptitudes, learning preferences, or styles prior to training and that can be adjusted, either in real time or at the end of a training session, to reflect the learner's on-task performance" (Landsberg, Van Buskirk, Astwood, Mercado, & Aakre, 2010, p. 9). Adaptive training is intended to enhance training outcomes over a given training period and to result in less variability in performance across the trainee population (Bloom, 1984). While adaptivity can be integrated in traditional instructor-led training, micro-adaptation in this context requires significant teaching experience and domain content knowledge (Putnam, 1987); as such, many instructors are unable to demonstrate effective micro-adaptive behaviors when delivering instruction (Clark & Yinger, 1977). Qualitative micro-adaptation involves adjusting the types of materials or feedback; quantitative micro-adaptation involves varying the amount of feedback, the number of questions used to assess learning, or the pace of learning (Schaefer & Dyer, 2012). These modifications are more feasible in CBT, which can modify instructional strategies incrementally in near real-time based on evolving trainee performance. Of particular importance is the capability to tailor performance feedback, which is considered to have both informational and motivational qualities (Bransford, Brown, & Cocking, 1999; Salas & Cannon-Bowers, 2000). Feedback is considered necessary for effective training, as it helps shapes the perception, action, or cognition of the trainee (Mayer & Johnson, 2010; Moreno, 2004). Feedback that is adapted to proximal trainee performance more effectively guides learning. Human instructors generally exhibit difficulty in detecting misconceptions and false beliefs on the part of the trainee, and frequently fail to effectively utilize this information even when it is provided in order to correct erroneous beliefs or behaviors (VanLehn, 2011); as such, the ability of the human instructor to provide the feedback necessary for effective training is often constrained by the instructor's ability to fully perceive proximal trainee performance and the underlying errors. Given the capacity for micro-adaptation in CBT, misbeliefs and misconceptions are more likely to be identified and corrected via timely and productive feedback. However, despite the many benefits of adaptive training, there is a lack of consensus in the literature regarding best practices for delivering feedback in a training environment (Serge et al., 2013). While CBI is proposed to be an instructionally sound delivery method for learning (Blotzer, 2000; Wilson, 2000), given that training outcomes may be of high criticality, it is important to conduct ongoing evaluations of the effectiveness of technology driven training such as CBI.

In doing so, motivational factors, peer and supervisory support factors, self-efficacy, demographic factors, and organizational climate should be assessed, as they contribute to the expression of training transfer back to the job, which is the chief aim of training in general. This type of evaluation is particularly important given concerns regarding the absence of human aspects of interaction in CBT (Sullivan, 1998), such as how the lack of peer interaction (Rand, 1996) and instructor feed-back (Rodriguez, 1999) increase the necessity of self-motivation for learning. Training transfer can be generally thought of as a function of motivation, ability, and environmental factors at three outcome levels: learning, individual performance, and organizational performance (Baldwin & Ford, 1988). It is important that the characteristics that either promote or hinder the transfer of training are evaluated on an ongoing basis.

Positive transfer of training entails trainees using what they learned in training back on the job. In order for positive transfer of training to occur, trainees must generalize the learned material to the job content and maintain the use of trained knowledge or skills over time (Baldwin & Ford, 1988). More recent approaches to transfer of training research have focused on the importance of trainee characteristics and the environmental context as mediators of the effectiveness and maintenance of training; this approach is in contrast to early transfer of training research which strictly emphasized training design characteristics. Baldwin and Ford (1988) advocate that individual differences, work environmental context, and training design characteristics influence training transfer with regard to generalization and maintenance. Broad (1997) notes that many previous approaches to training overemphasized the achievement of learning alone, neglecting assessments of whether workers achieved transfer. Essentially, it is important to determine whether trainees can apply learned knowledge and skills to a new problem or situation (generalization) (Bransford & Schwartz, 1999), and whether this preparation for novel situations is sustained over time (maintenance). Trainee motivation effects a large impact on the long-term effectiveness of a CBT training intervention, given the absence of the human aspects of interaction during training.

In general, motivation refers to a set of internal processes including arousal and both direction and intensity of effort (Colquitt, LePine, & Noe, 2000; Kanfer & Ackerman, 1989; Mitchell & Daniels, 2003). Noe (1986) modeled motivation as an influence on training effectiveness, finding that motivation to learn and motivation to transfer are critical mediating factors. Motivation to learn entails a trainee's desire to learn the content of the training and is generally considered inherent prior to training (Noe & Schmitt, 1986). Motivation to transfer refers to the trainee's desire to apply the learned knowledge and skills on the job (Noe & Schmitt, 1986). These factors impact the long-term effectiveness of training when viewed in terms of goals rather than task proficiency; trainee motivation is of particular importance when training is delivered via CBI.

Utility perception is another trainee characteristics that may mediate the effectiveness of training and the maintenance of transfer. Utility perceptions refer to the perceived usefulness or applicability of training to the trainee's job (Alliger, Tannenbaum, Bennett, Traver, & Shotland, 1997; Warr & Bunce, 1995). Utility perception should be assessed such that it is distinct from a trainee's perceived enjoyment of the training. Warr and Bunce (1995) have noted that trainees may find training highly enjoyable without learning anything useful for the job, and vice versa. Utility perceptions have demonstrated a stronger relationship with transfer of training than have affective reactions to training (Blume,