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Developing Job Specific and General Training Content and Assessments

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DEVELOPING JOB SPECIFIC AND GENERAL TRAINING CONTENT AND ASSESSMENTS

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Organizations, particularly airlines, would benefit from training programs that are reusable across multiple occupational contexts. We have developed a framework incorporating the notions of identical elements and general principles for designing job specific and reusable training content and assessments. We developed training programs based on the framework and empirically evaluated how it addresses training needs. Results of the study suggest that the identical elements design is beneficial in specific training contexts, while a combination of the identical elements and general principles designs may support reusability.

Introduction

While airlines could design completely separate training programs for pilots and flight dispatchers, this is not efficient. Therefore, airlines would benefit from the knowledge of how to create reusable training as well as the necessary role-specific knowledge for each program.

This training design process begins with understanding each employee's role in an organizational context. Understanding learner roles allows an instructor to operationally define training objectives that become the foundation for training content and assessment. The relationship between objectives, content, and assessment is known as *alignment* and has been accepted by instructional system designers as a standard for developing effective instruction (Cohen, 1987). In organizational training programs, alignment implies the use of *identical elements*. Identical elements is a concept that suggests a training program is more effective if training elements are identical to the operational context. Unfortunately, identical elements training designs are less effective when learners are faced with novel situations (Subedi, 2004) or there is a need for training that is reusable across multiple roles.

Achieving reusability requires a more general approach to the design of training. Theories suggest that learners are more likely to apply concepts in novel situations when they are exposed to general principles (Goldstein, 1986). In an organizational setting, general principles are abstract concepts and assumptions that "underlie" the skills and behaviors taught in role-specific training (Goldstein, 1986). Designing training for re-use begins with deriving abstract knowledge from multiple role-specific contexts. An overlap of the abstract knowledge between those roles is a general principle. The objective of general principles training is the successful application of concepts across all roles for which the training was targeted.

Evaluating whether a training program meets its objectives through assessment is critical to the design process. Assessments for role-specific (identical elements) training support alignment by utilizing problems or tasks that resemble those encountered on the job. Because there is not always a direct mapping to how learners apply the knowledge learned in general principles on the job, assessments for general principles training can evaluate potential for re-use of training as well as its effectiveness. Measuring potential for re-use involves evaluating learner retention and understanding. To assess reusability, learners must be given the opportunity to practice application of general principles concepts in a variety of novel contexts. Therefore, general principles assessments should also include tasks and problems from the role-specific contexts used to derive the general principles training.

To investigate the effectiveness of identical elements in role-specific training, we developed two training programs (including content and assessment materials) for flight-dispatcher and pilot weather decision making. Assessment materials consisted of job-like tasks aligned with the objectives of each training design. If identical elements benefit role-specific training designs, we would expect: 1) the flight dispatcher training group would perform significantly better on flight dispatcher tasks than the other tasks, and significantly better on flight dispatcher tasks than the pilot training group; and 2) the pilot training group should perform significantly better on pilot tasks than on the other tasks, and significantly better on pilot tasks than the flight dispatcher training group.

To investigate reusability of training, we developed a general principles training program (including content and assessment materials) from the overlap of abstract concepts derived from the flight dispatcher and pilot training programs. If the general principles training group performs significantly better on general principles (retention) tasks than the two identical elements training groups, the potential for reusability exists. The general principles training can then achieve re-usability in the flight dispatcher and pilot contexts if the general principles training group: 1) performs significantly better on flight dispatcher tasks than the pilot training group, and 2) performs significantly better on pilot tasks than the flight dispatcher training group.

Methods

Participants

19 male and 17 female university students between the ages of 19 and 24 (M = 21.0 years, SD = 1.3) who had completed or were currently enrolled in an atmosphere and weather course participated in the study. This group had interest in meteorology and equivalent, or more, meteorological education than pilots and flight dispatchers who have been through certification training (Bass and Quil, 2003). None of the students had taken any additional weather related coursework. The students were paid $40 for their participation. In addition, the highest performing participant in each training group was paid a bonus of $50 as an incentive.

Apparatus

Training Content. The focus of the training was on atmospheric icing. The training covered four content areas plus a section describing the structure and format of the training. The training provided background knowledge on aerodynamics and aircraft anti-icing and de-icing concepts. It also provided content on basic meteorology concepts. The training covered icing type and icing severity. Three versions of icing type and severity content were created: flight dispatcher, pilot, and general principles. For detailed descriptions of the design of the training content see DeVoge and Bass (2007).

Pretest and Posttest. Pre- and post-training knowledge evaluations were used to assess participant engagement with the training material and to investigate the equivalency of the training groups. Two test versions (Test A and Test B) were developed. Each test was comprised of multiple-choice, true/false, and fill-in-the-blank questions.

Operational Tasks. 24 operational tasks were developed to assess the three icing type and severity training sections: eight flight dispatcher tasks, eight pilot tasks, and eight general principles tasks. For detailed descriptions of the design of the operational tasks see DeVoge and Bass (2007).

INDEPENDENT VARIABLES

Training Group. Training Group refers to the version of icing type and severity training that participants received: flight dispatcher, pilot, or general principles.

Operational Task Type. Operational Task Type refers to three levels of icing type and severity identification tasks: flight dispatcher (F), pilot (P), and general principles (G).

Task Order. Task Order consisted of six levels used to counterbalance the order in which participants experienced the three operational task conditions: FPG, FGP, PFG, PGF, GFP, and GPF.

Test Order. To account for potential differences in the difficulty of the tests, half of the participants received pre-test A and post-test B, and half received pre-test B and post-test A.

The two main factors of interest in this study were Training Group and Operational Task Type. Test Order and Task Order were used to ensure no bias had occurred in the assignment of participants to groups, and to eliminate possible order effect confounds.

Dependent Variables

Pretest Score. Ten parallel questions from Test A and Test B were used to calculate the pre-test score for each participant. Participants were awarded one point for each correctly answered question on the pretest (maximum total of 10).

Posttest Score. As with the pretest, ten questions were used to calculate the posttest score for each participant (maximum total of 10).

Operational Task Score. An operational task score was recorded from answers given by participants on each of the three Operational Task Types. Each correct response on an operational task was worth one point for a total possible operational task score of 8 for each Operational Task Type.

Procedure

After completing a consent form, participants filled out a demographic questionnaire. The participants were then randomly assigned to one of the three training groups: the flight dispatcher training group

(n = 12), the pilot training group (n = 12), or the general principles training group (n = 12). After assignment to a training group, participants completed one of the two web-based knowledge evaluations (pretest). They then completed the web-based training. After a short break, participants completed the other knowledge evaluation (posttest). Participants then completed the three sets of operational tasks. The complete experimental session lasted less than two hours.

Design and Data Analysis

This study was a repeated measures design with Operational Task Type as the within subject factor and Training Group, Task Order, and Test Order as between-subject factors. The experiment utilized single replicates for the 36 (2 x 3 x 6) between subject conditions.

Test Order effects on pre and posttest scores were analyzed using the Mann-Whitney U test. Task Order effects on operational task scores were analyzed for all task orders using the Kruskal-Wallis test. Comparisons of pre-test scores across Training Group and posttest scores across Training Group were conducted using Kruskal-Wallis Tests. All paired-comparisons for the pre and post training knowledge evaluation scores were conducted using the Wilcoxon Signed Rank Test. The Friedman Test was used to conduct within training groups comparisons of operational task scores across Operational Task Type. For each Friedman test that returned significant results within a training group, paired comparisons of operational task scores by Operational Task Type were conducted using Wilcoxon Signed Rank Tests. Kruskal-Wallis Tests were used to conduct between training group comparisons of operational task scores by Operational Task Type. In addition, Mann-Whitney U Tests were used to conduct paired between group comparisons of operational task scores by Operational Task Type.

Results

Results for the experimental effects are reported using $\alpha = 0.05$ for significance and $\alpha = 0.1$ for trends.

Pretest and Posttest

No significant difference on pretest or posttest scores across the three training groups was found, eliminating the potential confound of individual knowledge differences between participants. Further discussion of the pre and posttest results can be found in DeVoge and Bass (2007).

Operational Task Scores

Table 1 summarizes task scores for the flight dispatcher, pilot, and general principles training groups across all operational tasks.

Table 1. Operational Task Scores by Training Group and Operational Task Type

Training Group	Operational Task Type	Mean	SD	Median
Flight Dispatcher (n=12)	F	6.58	1.44	7
	G	4.25	1.42	4
	P	3.58	1.73	3
General Principles (n=12)	F	4.92	1.17	5
	G	5.83	1.27	6
	P	3.75	1.36	4
Pilot (n=12)	F	4.17	1.53	4
	G	5.25	0.87	5
	P	5.42	1.98	5.5

Task Order. The order in which participants experienced the operational tasks did not significantly their operational task scores for any of the operational tasks. Further discussion of Task Order and operational task scores can be found in DeVoge and Bass (2007).

Identical Elements Training. The results suggest that identical elements ultimately support role-specific training. Within the flight dispatcher training group, scores varied significantly across Operational Task Type ($\chi^2 = 16.044$, df = 2, $p < 0.001$). In particular, participants in the flight dispatcher training group had significantly higher operational task scores on flight dispatcher tasks than on both general principles tasks ($z = 2.729$, N-Ties = 11, $p = 0.003$, one-tailed) as well as pilot tasks ($z = 3.071$, N-Ties = 12, $p = 0.001$, one-tailed). As identical elements would suggest, participants who were trained with the flight dispatcher training performed best on flight dispatcher operational tasks. There was no significant difference within the flight dispatcher training group between pilot operational task scores and general principles task scores. This is not surprising given the flight dispatcher identical elements training was not meant to benefit performance on unrelated tasks. In further support that the flight dispatcher identical elements training can benefit the flight dispatcher context, participants in the flight dispatcher training group performed significantly better on flight dispatcher operational tasks than participants in the pilot training group ($U = 17.500$, $N_1 = 12$, $N_2 = 12$, $p < 0.001$, one-tailed) as well as participants in the general principles training group ($U = 29.500$, $N_1 =$

12, N_2 = 12, p = 0.006, one-tailed). This suggests that the flight dispatcher identical elements training was the best training design (of the three) for achieving high scores on flight dispatcher operational tasks.

Within the pilot training group, participants exhibited significantly higher pilot operational task scores than flight dispatcher operational task scores (z = 1.667, N-Ties = 9, p = 0.048, one-tailed), a result that suggests the pilot identical elements training benefits the pilot context. The pilot training group also exhibited a trend for higher general principles task scores than flight dispatcher operational task scores (z = 1.594, N-Ties = 12, p = 0.056, one-tailed). The pilot group, however, did not exhibit significantly higher pilot operational task scores than general principles task scores. In fact, the pilot group's scores were high (in comparison to their flight dispatcher operational task scores) for both. This result is interesting for two reasons. First, the same result was not found within the flight dispatcher training group. Second, it does not support nor negate the use of identical elements. That is, identical elements training is meant to support one role (in this case pilots) and should not provide the opportunity to score higher on one set of unrelated tasks versus another (i.e. general principles vs. flight dispatcher tasks). It only suggests that scores on related tasks (in this case the pilot tasks) would be higher than scores on the other identical elements tasks (in this case flight dispatcher tasks), which was the case in this study.

Between group results show additional support for the pilot identical elements training. That is, participants in the pilot training group had significantly higher pilot operational task scores than both participants in the flight dispatcher training group (U = 32.000, N_1 = 12, N_2 = 12, p = 0.001, one-tailed) as well as participants in the general principles training group (U = 38.500, N_1 = 12, N_2 = 12, p = 0.024, one-tailed). This result suggests that the pilot identical elements training was the best training (of the three) for achieving high scores on pilot operational tasks.

General Principles Training and Reusability. The results of this study partially support the general principles training design in creating the *potential* for reusable training. The *potential* for reusability was measured by comparing general principle task score across Training Group (Table 1). General principles task scores varied significantly across Training Group (χ^2 = 7.089, df = 2, p = 0.029). In particular, participants in the general principles training group had significantly higher operational task scores on general principles tasks than participants in the flight dispatcher group (U = 30.500, N_1 = 12, N_2 = 12, p = 0.007, one-tailed). However, they did not have significantly higher general principles task scores than participants in the pilot training group (U = 52.000, N_1 = 12, N_2 = 12, p = 0.133, one-tailed). Because the pilot training group also performed well on general principles tasks, it is difficult to determine the unique contribution of the general principles training in creating the potential for reusability. For training to successfully achieve reusability, the general principles training group would have to show the potential for reusability across all role-specific training contexts.

Our results show a trend that participants in the general principles training group had significantly higher flight dispatcher operational task scores than participants in the pilot training group (U = 48.000, N_1 = 12, N_2 = 12, p =0.089, one-tailed). This result did not occur for the pilot operational task scores

Discussion

The purpose of this study was to explore aspects of training design in an attempt to understand how content and assessment facilitate reusable and role-specific training programs. It is clear that training design is constrained by the context of the real world. Successful training, then, requires understanding the unique representations, or identical elements, of a concept across roles as well as what general principles apply.

The results of this study support the use of identical elements in role-specific training. With respect to atmospheric icing, text and symbolic cues were effective in the flight dispatcher training and assessment, and photographic perceptual cues were effective in the pilot training and assessment. This is not surprising given that flight dispatchers and pilots deal with icing concepts in two very different operational settings. Pilots have a realistic interaction with icing while flight dispatchers work in a virtual world of charts, maps, symbols, and textual codes. Showing a flight dispatcher a picture of ice on the wing of an aircraft would not help him identify the severity of ice in a graphical PIREP. Likewise, showing a pilot a graphical PIREP would not help him identify ice on the wing of the aircraft he is flying. Assessment of identical elements training, therefore, should model actual job-related tasks in order to preserve conceptual representations between training and the operational context.

While the task of "identifying ice" may have been the same between flight dispatchers and pilots, the conceptual and physical representation between the roles was quite different (photographs vs. symbols/text). In order to preserve the identical elements designs, we could not compare the same conceptual representations between the two contexts. Future studies, however, may find it beneficial to use similar conceptual representations when comparing training designs.

There is no general principles operational setting to inform general principles training design. General principles training is meant to serve as a means to benefit more abstract conceptual learning. General principles tasks, therefore, are meant to evaluate retention of this abstract conceptual knowledge. In this study, the pilot group performed well on general principles tasks, even though they were not exposed to abstract concepts in training. It is difficult to identify the cause: if this result is due to the design of the pilot training, or the design of the general principles tasks. One possible explanation is that the perceptual cues given to the pilot training group prompted additional consideration of the atmospheric conditions and physics behind the formation of icing. By viewing the photographs of ice crystals, the participants may have been encouraged to consider what atmospheric conditions would support the formation of different ice types or severities. An increased awareness of icing formation could have prepared the pilot training group for the general principles tasks, which would not have been the case with the flight dispatcher training group who viewed symbols and textual codes. The symbols and textual codes presented to the flight dispatcher group had no real physical connection to any underlying physical principles and therefore may not have encouraged further thought about the formation of ice. Future research efforts to investigate general principles assessments as measures of the potential for reusability should take more care in eliminating completely concepts from role-specific training.

While high scores on general principles tasks suggest the potential for reusability, they do not suggest that general principles training alone can effectively achieve reusability. This is shown through performance on role-specific tasks in novel situations. Although the general principles training group performed well on flight dispatcher tasks, they did not perform well on pilot tasks. One possible reason for their better success on flight dispatcher tasks than on pilot tasks is the cognitive similarity between the general principles training and the flight dispatcher training, with respect to the text-based training components. It is possible that greater cognitive similarity between general principles and identical elements results in a more effective overall general principles training design. Likewise, poor performance on pilot tasks could be a result of the cognitive disparities between the general principles and pilot training designs. That is, the pilot training focused primarily on visual icing cues while the general principles design focused on basic atmospheric weather variables (in text format). The general principles training and assessments may have included instantiations of general principles that did not concurrently benefit the flight dispatcher and pilot operational contexts. The use of role-specific instantiations of general principles rather than the overlap of abstract knowledge between roles may improve the design of general principles training and ultimately influence reusability.

Conclusions

The results of the study do provide insight into the design of organizational training programs. First, it is clear that identical elements designs are beneficial for training concepts and tasks that relate to specific operational contexts. On the other hand, it is clear that training identical elements alone is not enough to support the application of concepts across operational contexts.

General principles training may benefit application of concepts to tasks in varying contexts (e.g. flight dispatcher tasks), although it is clear that there are specific occupational training requirements that general principles may not directly support (e.g. pilot tasks). Furthermore, developing assessments to measure the potential reusability of general principles is a difficult academic exercise, and inherently problematic. It is clear, then, that the potential for reusability should be measured by the effect of general principles training on operational task performance. In this case, general principles training may best be utilized in combination with identical elements training in which operational task assessments can be used as measures of the effectiveness of both aspects of the overall training program.

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THE IMPACT OF HUMAN FACTORS RELATED INNOVATIONS ON AVIATION SAFETY: ORAL ONLY PRESENTATION

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The author examines the role that human factors innovations have played in improving safety in the various sectors of US aviation from 1981 to 2005. During this period the three major aviation sectors (the airlines, general aviation, and the military) have all made progress in reducing their accidents rates. However, statistics indicate the airlines have been much more successful than the general aviation or military sectors. The author offers explanations for this differential progress.

This quarter century was a dynamic period for several reasons, including the impact of the 1978 Airline Deregulation Act. Some experts had predicted that this legislation would degrade safety, because the new emphasis on reducing costs would supposedly prevent the airlines from adequately funding their safety programs. However, during this period other significant changes were occurring in both the government and the industry arenas that appear to have more than compensated for the expected airline funding shortfalls. These changes included the NTSB undertaking in-depth investigations into the underlying causes of human errors by established their Human Performance Division in 1981. Two years earlier the board issued their first airline Crew Resource Management (CRM) recommendation. Within a decade, this NTSB recommendation, with major assistance from academia, NASA and the FAA, dramatically enhanced airline training.

By the eighties, technological innovations also appeared. For example, devices such as Ground Proximity Warning Systems improved safety. This well-designed automation assisted airline pilots in making timely decisions to avoid Controlled Flight Into Terrain accidents, the major cause of earlier catastrophic airline crashes. Largely, because of a number of such technology and procedural innovations, airline accidents dramatically decreased during this time 25-year period. For instance, the major airline accident rate indices decreased by approximately 95 percent, (depending on which metric is used).

During this time frame the US general aviation accident rate improved by approximately 20 percent, (depending on the particularly metric selected). These rather modest safety gains can be explained by the more limited technology and procedural enhancements adopted by general aviation. For instance, Aeronautical Decision Making training, unlike airline CRM, was never fully implemented in the general aviation arena. Furthermore, some of these very limited improvements must be attributed to the better ergonomics of the later model general aviation aircraft entering the inventory in recent years.

During this period the overall US military accident rate improved by around 40 percent, (again, depending the metric). While better that the modest GA gains, these military gains did not approach the stellar airline improvements. Reasons for this shortfall are noted. For example, the military unlike the airlines, has never fully embraced CRM-type training. Another factor limiting military improvements involves significant funding shortfalls, which ironically was supposed to be an airline safety problem.