Direct vs. Problem-Centered Instruction in Army Training

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ABSTRACT

The Army Learning Model (ALM) calls for a transformation of classroom instruction from lecture-based direct instruction (DI) to "context-based, collaborative, problem-centered instruction" (PCI). Additionally, ALM purports that DI is more appropriate for well-defined training domains, such as how to fill in administrative forms, while PCI is more appropriate for ill-defined training domains, such as how to formulate a periodic counseling or job performance evaluation. However, a survey of current learning science does not yield unanimous support for these proposed transformations.

The research reported here sought to assess the effectiveness of the ALM prescriptions applied to training a typical Army task. A DI-based and a PCI-based version of an Army training module (Noncommissioned Officer (NCO) Evaluation Report Preparation) were constructed and each administered to Infantry Advanced Leader Course classes. The expectations were that (1) DI students would out-perform PCI students on tests of well-defined elements, and PCI students would out-perform DI students on tests of ill-defined elements and (2) the magnitude of the differences would warrant the addition of PCI.

The results showed that PCI was, as expected, more resource intensive than DI, but that, although all students had improved at course end, there were no practically significant differences between DI and PCI students on test items of either well-defined or ill-defined elements. The results confirm that the Army's transformation to PCI may in some cases yield no corresponding increase in training effectiveness to warrant the additional effort. The paper also addresses issues associated with quantitative comparison of different pedagogical models and issues associated with trading off training effectiveness vs. training cost.

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BACKGROUND

In the full development of military training, there are three considerations that must be balanced: theoretical aspects, administrative prescriptions, and practical constraints. In a perfect training world, all three considerations would ideally conjoin, each being consonant with and supportive of the other two. However, the world of military training is less than perfect. The research reported here addressed the real world nexus of these three considerations as was recently experienced for an instance of Army training and describes the degree of consonance and support that was obtained.

In reporting this research, we first elaborate on each of the three considerations and how each affected the design and objectives of the research. Then we describe how the research itself was conducted, report its outcomes, and discuss in some depth various implications.

Theoretical Aspects

Any training, military or otherwise, explicitly or implicitly follows some theory or model of training. Army training, since the late 1970's, has generally followed the instructional systems design model (cf. Gagne, 1985), as was recently embodied in the U.S. Army Training and Doctrine Command's (TRADOC's) 1999 now superseded Systems Approach to Training (SAT). The SAT lent itself well to the development of training courses based in what is generally termed "direct instruction" or DI. DI involves directly and specifically providing information that fully explains the concepts and procedures that students are required to learn (Kirschner, Sweller, & Clark, 2006). The SAT supported training design and development through decomposition: to-be-learned material was analytically progressively broken down into learning modules, and then the role of instruction was to present the modules as logical building blocks leading students to learn by re-composing the to-be-learned material. In this model, the student assumes a mostly passive role as the receiver of the to-be-learned material.

An alternative theoretical model of learning casts the student in a mostly active role. Termed "constructivism," this alternative holds that the student engages in purposeful interaction with the learning environment in an attempt to mentally construct the to-be-learned material and integrate it with the learner's existing knowledge structures. For this model, learning is the process of cognitively assimilating and making personal sense of the to-be-learned material and reconciling it with existing personal knowledge. The constructivist model posits that deep and perduring learning takes place when students actively cognitively contend toward understanding some problematic goal (Savery and Duffy, 1995). It is the "problematic" aspect of the constructivist model that fosters most current constructivist pedagogical approaches, such as problem-based learning, inquiry based learning, problem centered instruction, etc. In contrast to DI's re-composition, constructivist approaches tend to present the student with a fully composed problem which the student in turn solves by decomposing it into understandable and learnable parts.

Given the differences between the DI and the constructivist models of learning, it is not surprising that considerable research effort has been expended, both in the elaboration and extension of each model and in the comparison of the relative training effectiveness of each model. Elaboration and extension of DI has resulted in implementations such as the Army's recent investigation of guided experiential learning (Clark, 2004, 2007). Elaboration and extension of constructivist models has resulted in problem-centered implementations such as inquiry based learning (Duffy & Raymer, 2010) and invention learning (Schwartz & Martin, 2004).

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Comparison of the two classes of models' impact on training effectiveness has been problematical. Mayer (2004), after surveying studies of students solving classes of problems with or without direct guidance, concluded that without instructional guidance, students' arrival at a learning solution is very inefficient and many times ineffective. Kirschner et al. (2006) further claim there to be no significant empirical evidence that problem-centered approaches are more effective than DI approaches. Constructivist apologists have issued rejoinders (cf. Hmelo-Silver, Duncan, & Chinn, 2006), and constructivist researchers (e.g., Schwartz, Chase, Oppezzo, & Chin, 2011) have continued to demonstrate the efficacy of problem-centered approaches.

The current dialectic between proponents of DI and proponents of problem-centered approaches would appear from Tobias and Duffy's (2009) summary debates to be that DI may be more effective for a well-defined subject area such as filling in administrative forms, while problem-centered approaches may be more effective for an ill-defined subject area, such as periodic counseling or job performance evaluation.

Administrative Prescriptions

As indicated above, the U.S. Army's SAT has been superseded. Its successor is the somewhat less prescriptive Army Learning Model (ALM) (U.S. Army Training and Doctrine Command, 2011) which comprises the goal or end state for Army training by 2015. The ALM characterizes the 2015 institutional learning environment to be one in which "context-based, collaborative, problem-centered instruction" (p. 19) is the norm. To begin achievement of this norm, the ALM prescribes as a first step the conversion of "most classroom experiences into collaborative problem-solving events" (p. 9).

Accordingly, in fulfilling the ALM, Army schoolhouses are tasked with converting courses from a DI instructional format to a problem-centered instruction (PCI)[2] format.

Practical Constraints

Theoretical niceties and administrative fiats notwithstanding, Army training and education faces very real practical constraints on implementation. Aside from the major constraints associated with shrinking or reallocated funding, Army training faces constraints associated with its customer (the operational Army), with its physical plant, and with its instructional cadre. Another constraint that at times cannot be met is that of not implementing changes to training unless there is an assured concomitant increase in training effectiveness or efficiency. These constraints are discussed in more detail below.

For each course of instruction, the operational Army expects Army training to, in a minimum amount of time, deliver an expected number of course graduates trained to expected criteria. This expectation constrains both the length of courses and the face validity of any course completion test or examination. Self-paced courses are self-paced only to a degree, time for end of course tests is included in the overall course length, and end of course tests typically are reported as a percentage, with 70% being the minimum passable performance.

Classrooms and classroom facilities also impact training implementation. Standard sized classrooms may not scale well for small group instruction. The latest advances in learning technology may not be available in classrooms, thus constraining the opportunity to exploit technology.

Instructional cadre vary both in experience and in degree of preparation to be an instructor. Instructors can be civil service personnel or contractor personnel, but most are active Army personnel. An active Army Soldier is selected as an instructor based primarily on the rank and military occupational specialty required by the instructor billet, as a minimum attends a 2-week instructor training course, and then serves as an instructor for at most 3 years before moving on to a new assignment. Thus, training may be constrained by instructor turn-over and by instructor ability to adapt to changes in curriculum or in instructional method.

Any changes to training ideally should be based on empirical evidence that those changes will in some way improve the training. Also, because implementing changes to training consumes resources, there should be some assurance

[2] "PCI" is referenced in this report as it is applied in the ALM.

that the improvement will be substantive enough to offset the cost of the change. Unfortunately, this at times is a point of friction between administrative prescriptions and practical constraints.

A Real World Example

As indicated above, the research reported here is grounded in a real world example of the confluence of these three considerations. Under the above mentioned ALM prescription to implement PCI, the research team worked with the U.S. Army Maneuver Center of Excellence Henry Caro Non-Commissioned Officer Academy to demonstrate an application of PCI.

Drawing on the theoretical aspect of PCI being better suited for ill-defined (ID) subject areas and DI better suited for well-defined (WD) subject areas, an instructional module with both ID and WD content was selected. This module, "NCO Evaluation Report (NCOER) Preparation," appears in the Military Occupational Specialty (MOS) 11B Phase 2 Advanced Leaders Course (ALC) and had historically been presented in a mass lecture venue. For the research environment, it was decided to abandon the mass lecture for a small group instructional setting and, for the PCI conditions, to use Schwartz & Martin's (2004) "contrasting cases" PCI variant. Because "contrasting case" utilizes some DI, it was deemed potentially least disruptive if introduced to the ALC cadre. Although there are various approaches to assessing the effectiveness of PCI (e.g. Schwartz et al., 2011), the attempt was made to insofar as possible use a short answer, percent correct format similar to other ALC instruments. No classroom technology was used beyond the then available assets, and experimental versions of the NCOER training were designed to fit within the ALC's standard 4 hour block of training.

The primary experimental hypotheses were: (1) DI will be more effective than PCI for WD material, while PCI will be more effective than DI for ID material, and (2) the differences in effectiveness will be sufficient to warrant changing from a wholly DI model of instruction.

METHOD

Design Overview

The NCOER is an annual evaluation addressing the NCO's performance and suitability for increase in rank and responsibilities. In a typical unit, subordinates' NCOERs are prepared by Staff Sergeants (raters) based on the raters' assessment of their subordinates during the period being reported. While there are many WD entries involved in writing a good NCOER, there are additional ID requirements involved as well in writing narrative "bullet" statements to support the ratings on various NCO tasks, leadership dimensions and Army values. In general, the straightforward "fill in the blank" parts of the NCOER were regarded as the WD material and the narrative ratings and justifications were regarded as the ID material.

The design consideration was that the PCI and the DI instances should be made comparable and also be based on the best practices for both frameworks. Instead of using the NCOER mass lecture as the DI exemplar, a completely new DI version was constructed, working from the pre-ALM Army guidelines for developing training (U.S. Army Training and Doctrine Command, 1999). In addition to direct lecture, this new version also included numerous practical exercises and discussions to reinforce lecture points. The "contrasting cases" PCI version was developed using "invention" sequences of students solving an initial problem followed by problem focused direct instruction and discussion (cf. Schwartz et al., 2011).

Participants

Participants in the DI and PCI groups were 67 Sergeants (SGT E-5) and Staff Sergeants (SSG E-6) attending 11B ALC. Of these NCOs, 43% reported regularly using the NCOER system and, of those, 71% reported having experience at developing NCOER bullet statements and 64% reported having been the rater for two or more NCOERs.

The control group consisted of 30 ALC students. All had previously received the then-current 4-hour mass lecture block of instruction covering principles of Army writing and preparation of NCOERs.

Instructors

The same instructor conducted both the DI and the PCI classes. A member of the research team, this instructor was a trained, qualified educator, with experience in both DI and PCI methods. The DI/PCI instructor was also a subject matter expert (SME) in the area of NCOER preparation. A different SME instructor not associated with the research team conducted the mass lecture training for the control group as part of the normal 11B ALC cadre.

Measurement Instruments

The DI and PCI experimental groups were administered a demographic questionnaire and Pretest prior to instruction, and a Posttest and post training questionnaire subsequent to instruction. The control group was administered the Posttest only.

The Demographic Questionnaire consisted of 11 items presented in multiple choice or short answer formats addressing students' general background and their experience in preparing NCOERs.

The Pretest involved students role playing a squad leader faced with completing an NCOER for a fictitious Soldier in his squad. In support of the test scenario, students were provided with NCOER reference material, partially completed forms, and the fictitious Soldier's file containing miscellaneous orders, records, and notes. The test consisted of 17 items ranging in format from multiple-choice to open-ended question to job sample. The job sample items included writing evaluation bullets for the fictitious Soldier.

The Posttest consisted of 15 items also presented in multiple choice, short answer, and job sample formats. The Posttest was structured to parallel the Pretest but the scenario-based materials involved a different (fictitious) Soldier.

The Post Training Questionnaire consisted of 21 items presented in Likert-type or short answer format. The questionnaire addressed (1) Soldiers' perceived level of understanding of the NCOER process before and after instruction and (2) their attitudes toward the effectiveness of the instruction.

Procedure

The overall sequence of events for addressing training effectiveness is given in Figure 1 below. Details of the figure appear in the sections following.

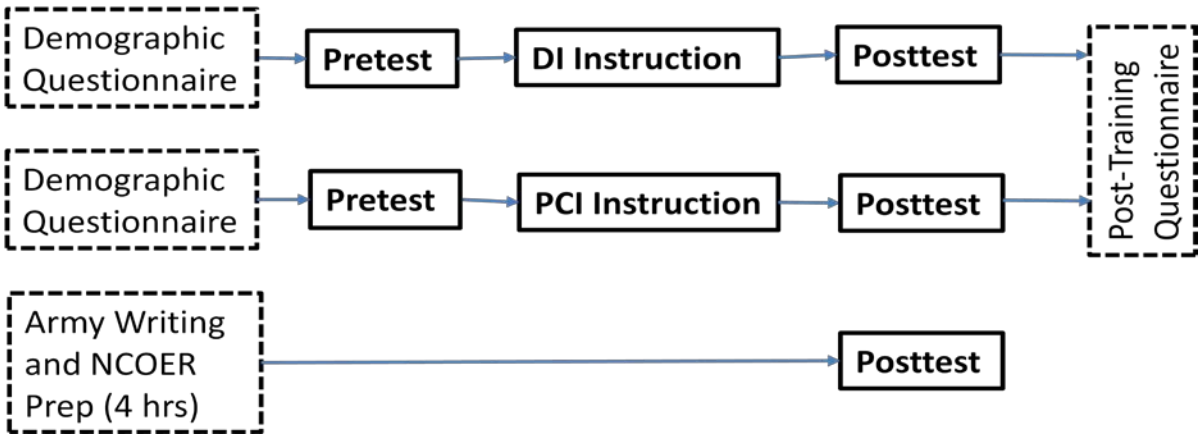

Figure 1. Design of training effectiveness assessment.

Experimental Condition: PCI. All experimental groups were of a nominal size of 16 students. At the start of a session, first the students were briefed on the purpose of the experiment, and then they completed the Demographic Questionnaire and the Pretest.

Next, the class was divided into two-man teams. Each team was provided with forms/information prepared by a fictional former squad leader for two fictitious Soldiers. The student teams read through the folders and contrasted profiles of the two fictitious Soldiers to help gauge their understanding of the Soldiers' performance and to assess the former squad leader's ability to write good bullets and to provide accurate assessments, counseling and follow-up feedback.

The instructor then facilitated a group discussion on the evaluations of the two fictitious Soldiers and on the former squad leader's efforts. Following the discussion, the teams then wrote bullets on specific values, attributes, skills, and actions with each team addressing a different category. This bullet writing comprised the invention phase of the PCI module.

The instructor collected each team's bullet and displayed them (separately) on an overhead projector for class review and feedback guided by the instructor. After all bullets had been presented, the instructor provided a brief review (lecture) to reinforce key teaching points.

This process was repeated two more times. For each of the three iterations, the profiles presented for each practical exercise were each designed to contrast the differences among NCOERs for high, average, and low performing Soldiers. The instructional cycle captured the essence of contrasting cases/invention: comparison of multiple examples (differing profiles), invention (writing bullets), followed by small group discussion, feedback, and follow-on lecture highlighting key points in each practical exercise. Following the third exercise and lecture, the PCI students completed the Posttest, and the Post Training Questionnaire.

Experimental Condition: DI. DI students were treated as were the PCI students up through division into two-man teams. Following dividing the class into teams, the instructor addressed the importance of having an evaluation system and the role of the rater. He then presented a 45 minute lecture reviewing the different parts of the NCOER and giving guidelines for the completion of each part.

Following the lecture, the instructor distributed the same NCOER materials used in the PCI module but with student teams receiving information on only one fictitious Soldier at a time. Student teams read through the materials and then wrote bullets for this fictitious Soldier. As with the PCI module, the instructor displayed the bullets for class review and feedback. The instructor provided additional feedback and then re-emphasized key teaching points. This process was repeated two more times. Each practical exercise was different and designed to provide examples supporting specific instructional objectives. Following the last exercise, the DI students completed the Posttest and the Post Training Questionnaire.

Control Condition. Students in the control condition had previously completed the then-current 11B ALC 4-hour module covering NCOER preparation and Army writing. They completed the same Posttest that was administered to the DI and PCI students.

RESULTS

The results below characterize students' perceptions of the value of the two types of training and then show students' actual performance subsequent to the two types of training.

Student Perceptions of Training Value

Figure 2 shows that PCI students valued their training more than did the DI students across every item on the Post Training Questionnaire (the items are listed in Table 1). The PCI vs. DI difference in perceived value was significant for Item 5, $t(54)=2.174$, $p<.05$; Item 7, $t(55)=2.256$, $p<.05$; and Item 10, $t(55)=2.491$, $p<.05$.

Table 1. Items Relating to Perceptions of Value of Training

	Item – "The instruction…"
1	Gave me a much better understanding of the NCOER process.
2	Prepared me to perform my duties as a rater.
3	Prepared me to develop more meaningful and accurate NCOERs.
4	The time devoted to explaining concepts was adequate.
5*	Covered issues and nuances in the NCOER process that were very helpful.
6	Provided valuable insights on how to effectively develop appropriate bullets for an NCOER.
7*	Improved my ability to write an NCOER that accurately represents the NCO's performance.
8	Provided me a better appreciation for accessing and using Army publications.
9	Assisted me in knowing what I need to do to receive an "Excellent" rating.
10*	Has motivated me to ensure my subordinates receive accurate NCOERs.
11	Has motivated me to ensure that my NCOER accurately reflects my performance.

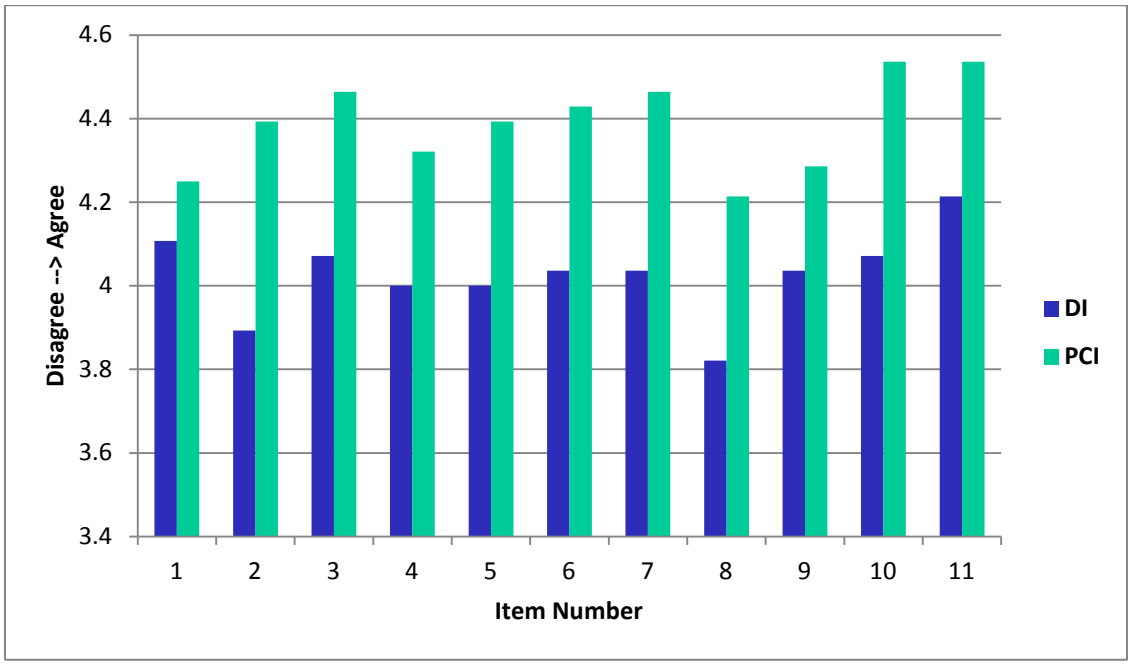

Figure 2. Mean ratings for perception of instructional value by experimental condition and item.

Objective Performance

Participants' performance on well-defined (WD) items addressed their understanding of well-defined rules for the completion of NCOER sections that have objectively correct answers. Similarly, participants' performance on ill-defined (ID) items addressed their skills relating to NCOER knowledge and bullet writing.

Figure 3 illustrates the overall effectiveness measurements for the DI and PCI students. A three-way (2x2x2) mixed factor analysis of variance (ANOVA) was conducted on task score. The independent variables were experimental condition (DI vs. PCI), time (pre vs post), and task type (WD vs ID). There was a significant overall increase from pre- to post- ($F_{1,56}$=134.716, (p)< 0.001), but there were no significant interactions. In particular, DI was no more effective than PCI for WD material, while PCI was no more effective than DI for ID material

To determine how well the two experimental training modules fared relative to the control group (Figure 4), a two-way (3X2) mixed factor ANOVA was conducted on Posttest task score. The independent variables included group (DI, PCI, and Control) and task type (WD vs ID). There was a significant difference among the DI, PCI, and

Control groups ($F_{2,84}$=5.558, p<0.005). Additionally, there was a significant interaction between task type and group ($F_{2,84}$=13.751, p<0.001). Simple main effects analysis demonstrated that the Posttest scores for the WD tasks did not differ significantly for any of the groups ($F_{2,84}$=0.169, *MSE*=0.020, *p*=0.845), but the groups' Posttest scores for ID tasks did differ significantly ($F_{2,86}$=23.438, *p*<0.001). Post hoc Tukey tests (at p≤0.05) indicated that the Posttest score for ID tasks of the Control group was significantly lower than either the DI or PCI group (See Figure 4).

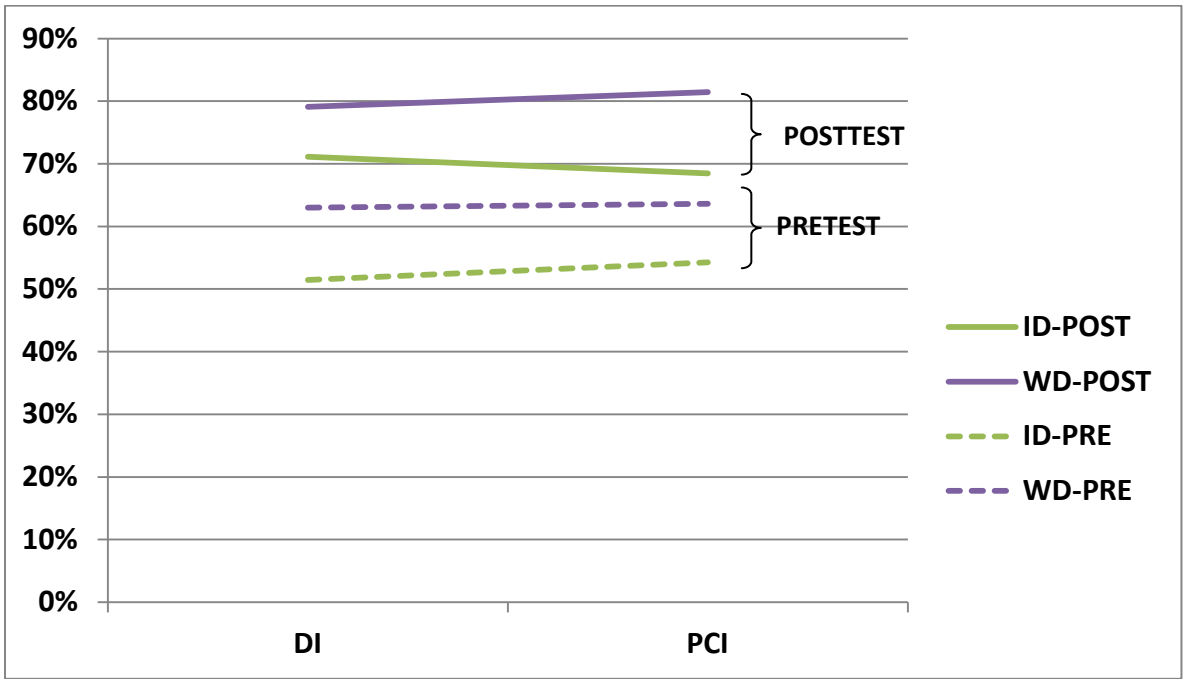

Figure 3. DI and PCI students showing overall difference between Pretest/Posttest and between ID/WD

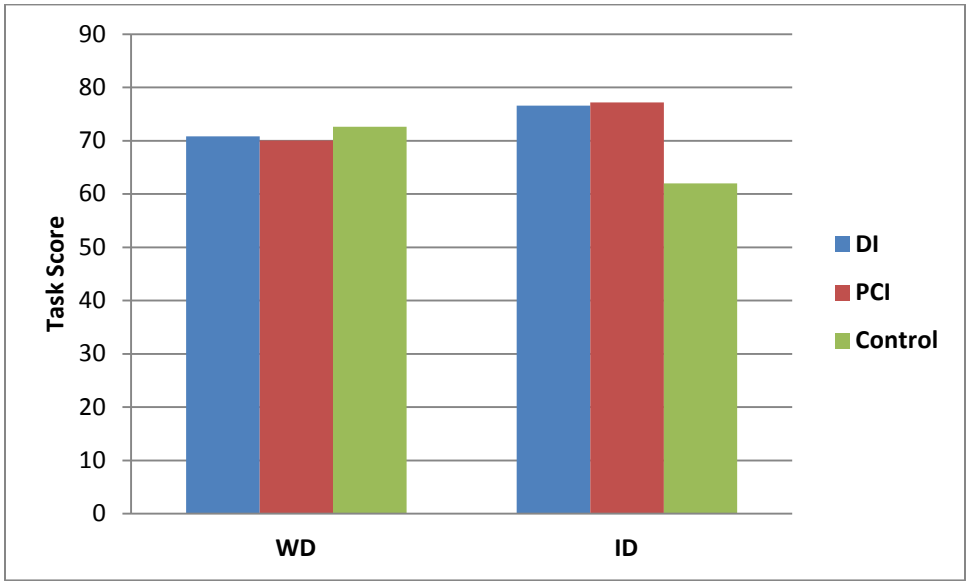

Figure 4. Comparison of the Posttest scores for well-defined (WD) and ill-defined (ID) tasks by experimental group.

DISCUSSION

Overview

ALC 2015 recommends a shift towards more learner-centered, experiential instructional methodologies under the overarching assumption that in many cases this shift will result in more effective training. This research sought to examine the effects of such a shift within typical Army training constraints. The research was situated in a typical on-going Army institutional training environment, utilized typical Army students, and employed typical Army assessments of learning. Thus it was expected that any statistically significant results would likely also be operationally significant, and, more importantly, that statistically non-significant results would have no operational significance to the Army.

The research evaluated the relative effectiveness of a PCI module to that of a DI module and to the training the students then currently received in ALC. Previous studies suggest that PCI should be better suited to training abstract and ill-defined tasks and DI should be a more effective methodology for well-defined, procedural tasks. Both the PCI and DI modules were found to significantly improve student scores on tasks related to NCOER completion from Pretest to Posttest. The results did not support our hypotheses of differential effectiveness of the PCI instructional methodology compared to DI for the more ill-defined NCOER completion tasks. However, despite similar performance on the measures, there were significant differences in the students' perceptions of their training.

The absence of the anticipated significant interaction between instructional approach and instructional domain has two alternative implications: (1) there is no significant differential effect of instructional approach or (2) there actually is a significant effect, but the present research failed to detect it. These two alternatives are discussed in some detail below.

No Difference between DI and PCI Approaches?

There has been a widespread caution (cf. Kirschner, Sweller & Clark, 2006; Mayer, 2004) that PCI approaches are at best no more effective than are DI approaches. More recently, Benson (2012) concludes that there is no compelling empirical evidence to support mandating PCI as a superior pedagogy, but on a positive note concludes that, since it appears to be equivalent to DI, PCI might be adopted for reasons other than training effectiveness. Onyon (2012) also concludes that compelling evidence for adoption of PCI remains undetermined and further suggests that more effort be made to explore implications of some of the theoretical underpinnings of PCI.

The result of this particular research is certainly congruent with previous findings of indeterminate differences. The equal end-of-course performances of the DI and the PCI classes would indicate no operationally significant difference between these two instantiations of the approaches. The inference could be made that, if instruction be well crafted, either as per DI principles or as per PCI principles, the result will be effective, at least as typically assessed by the Army.

A Real, but Undetected Difference?

On the other hand, there remains the possibility that there was some difference in learning, but that the difference was not captured by this research. Indications that the two instructional approaches were at some level not completely equivalent come from differences between the DI and PCI students' perceived value of the training.

Student perceptions of the training module's value were more positive in the PCI condition. It is possible that the students in the PCI condition viewed the instruction more favorably for several reasons. Increased PCI workload on exercises relative to DI may have influenced PCI students' perceptions. The greater cognitive demands placed on PCI students may have led students to believe that more work/effort expended in training produced better understanding of material and higher levels of perceived performance or competency.

There is the possibility that the primary dependent measures themselves used in this research somehow are insensitive to real differences between the two instructional models. For example, additional alternative or complementary measures, such as response latency, response confidence, etc. might be sensitive enough to detect

significant differences between DI and PCI approaches. However, practical constraints on measurement methods would make many of these methods untenable.

Additionally, there is the possibility that PCI-instructed students might out-perform DI-instructed students on a subsequent far transfer task, such as the fairly common Army administrative task of drafting citations for personal awards. Schwartz and Martin (2004) found such an advantage for contrasting cases/invention. However, in later work Schwartz, Chase, Oppezzo, and Chin (2011) examined the effectiveness of contrasting cases when some students are presented the to-be-learned concepts prior to being presented the contrasting cases and others presented the concepts after being presented the contrasting cases. Schwartz et al. found that, although both groups of students performed approximately equivalently on the to-be-learned task, students who were presented the to-be-learned concepts after the contrasting cases performed better on a related far transfer task. Schwartz et al. conclude that, when students experience the initial "inventing" of the to-be-learned concepts before being formally presented the concepts, the underlying deep structures are better learned and, consequently, far transfer is made easier. In the present research, given that 70% of the students had already participated in preparing NCOER bullets and, thus, presumably had some concept of the NCOER preparation task, and given that they had completed the Pretest, it is unlikely that the PCI group experienced any appreciable "inventing" during instruction.

The foregoing considerations suggest areas for further research into the theoretical aspects of PCI methods. However, for purposes of the present research, the fact remains: for typical Army students in a typical Army environment using typical Army training assessment measures, there was no operationally significant difference found between the two approaches.

Current method vs. DI/PCI. Although the then current method was found less effective than DI/PCI, there is the possibility that DI/PCI would be, relative to the current method, much too resource intensive to warrant developing and sustaining a new method of instruction. This then raises the practical question for training developers: is the gain in effectiveness attributable to the DI/PCI methods (cf. Figure 4) worth the additional resources required to implement the DI/PCI methods? In particular, is the additional skill at ill-defined aspects of preparing NCOERs worth the additional resources? A quantitatively supported answer to these questions is outside the scope of the present effort, but these are examples of issues that may arise and the data that may be required to address them when training effectiveness is traded off against training efficiency.

DI vs. PCI. If it be the case that the gain in effectiveness due to the DI/PCI methods outweighs the additional resources required to implement them, then the question arises as to whether there are requirements differences of a magnitude to recommend one method over the other. As was anticipated, the PCI method required more resources in development than did the DI method. However, there was no off-setting increase in effectiveness associated with the PCI method. Thus, unless the students' increase in perceived understanding and increase in perceived value more than offsets the resource differential, in a decision to adopt either the DI or the PCI method, the training developer within practical constraints would choose the DI method.

Conclusions

The results of this research support the cautions (e.g., Kirschner et al., 2006; Mayer, 2004) that have been raised concerning indiscriminate application of PCI methods. Although the ALM prescribes that the Army embrace "context-based, collaborative, problem-centered instruction," these results indicate that, in at least some cases, there may be no benefit of problem-centered instruction over direct instruction. This research indicates that it is possible using best practices within a typical Army institutional training environment to design both PCI and DI that are equivalent in their training effectiveness, as typically measured in that institutional environment. Additionally, the research shows the equivalency can hold regardless of whether the subject domain is well-defined or ill-defined.

However, just as PCI should not be indiscriminately applied, so should the results of this research not be indiscriminately applied to all training. The results by no means indicate that well executed DI and PCI are equivalent – the results should rather be interpreted as a caution for training developers that in many cases any relative effectiveness advantage to either method may not be operationally relevant.

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