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ABSTRACT

Most representations of academic disciplines have been created when experts depict or report what they know; however, there are potential problems that can arise when practitioners rely on expert self-report. One way to avoid potential problems associated with expert self-report is to employ cognitive task analysis methods. The Pathfinder Scaling Algorithm is one such method. This software program transforms participants' pair-wise ratings of related concepts into a semantic network-a concept map comprised of nodes (the concepts) and links that depict the relationships among the concepts. Using the Pathfinder Scaling Algorithm (Pathfinder) (Interlink, 1994), the researchers conducted a cognitive task analysis expertise in Human Performance Technology (HPT). The study investigated: the extent to which Pathfinder-derived coherence scores were associated with other measures of HPT expertise; how HPT experts organize their knowledge of the discipline; and how experts organize their HPT knowledge differently than novices. Findings include: a significant correlation between coherence and the number of HPT-related books participants had written; a Pathfinder-derived concept map of HPT; and expected novice/expert differences in Pathfinder similarity and relatedness scores. (Contains 26 references.) (Author/AEF)

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A Cognitive Map of Human Performance Technology: A Study of Domain Expertise

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Abstract

Using the Pathfinder Scaling Algorithm (Pathfinder) (Interlink, 1994), the researchers conducted a cognitive task analysis expertise in Human Performance Technology (HPT). The study investigated: 1) the extent to which Pathfinder-derived coherence scores were associated with other measures of HPT expertise; 2) how HPT experts organize their knowledge of the discipline; and 3) how experts organize their HPT knowledge differently than novices. Findings include: 1) a significant correlation between coherence and the number of HPT-related books participants had written; 2) a Pathfinder-derived concept map of HPT; and 3) expected novice/expert differences in Pathfinder similarity and relatedness scores.

Most representations of academic disciplines have been created when experts depict or report what they know. Experts draw diagrams, establish competencies, and write textbooks. Clearly, this approach works; new practitioners use these representations to enter and gain competency in the discipline. Some practitioners eventually master elements of the discipline. However, there are potential problems that can arise when practitioners rely on expert self-report. Simply stated, experts are often unable to state what they know and do that makes them experts. Two cognitive processes account for this phenomenon. First, experts may be unable to explicitly state knowledge they have learned implicitly. Implicit learning occurs when people acquire knowledge about the relationships comprising a complex system, without necessarily knowing in advance what the variables are. Examples include solving differential equations underlying a simulated parking task (Broadbent, Fitzgerald, & Broadbent, 1986) and predicting where a light will appear on a computer screen in a serial learning task (Willingham, Nissen, & Bullemer, 1989). In these situations, people have encountered a complex task, observed the variables in operation in an unselective manner, and attempted to store the contingencies among them (Berry, 1993). Essentially, people implicitly learn these complex system and the relationships comprising it by "mucking about." One of the results of implicit learning is that the resulting knowledge is relatively inaccessible to free recall (Berry, 1993). Experts who have implicitly constructed domain-specific knowledge may not be able to articulate what they know.

Second, experts may be unable to articulate cognitive processes that have reached a level of automaticity. According to Anderson (1993), this situation exists when people explicitly learn new skills or knowledge by using language to mediate a cognitive production, such "determine the cause of a performance gap" or "select an appropriate intervention to address the cause of the gap." With successive tuning, the production fires automatically, without invoking any mediating language. The result is automatic, fluent performance—without the ability to report on the cognitive aspects of the performance itself.

One way to avoid potential problems associated with expert self-report is to employ cognitive task analysis methods. The Pathfinder Scaling Algorithm is one such method (Schvaneveldt, 1990; Interlink, 1994). This software program transforms participants' pair-wise ratings of related concepts into a semantic network—a concept map comprised of nodes (the concepts) and links that depict the relationships among the concepts.

A Pathfinder-derived concept map of a discipline could supplement existing representations created using expert self-report. One opportunity for using Pathfinder to map a discipline lies in the area of human performance technology (HPT): "...a set of methods and procedures, and a strategy for solving problems, for realizing opportunities related to the performance of people. It can be applied to individuals, small groups, and large organizations" (ISPI, 2001). As no cognitive task analysis of HPT has been conducted to date, this study sought answers to the following three research questions:

1. To what extent are Pathfinder-derived coherence scores associated with other measures of HPT expertise?
2. How do experts in the field organize their knowledge of HPT?
3. To what extent do experts organize their HPT knowledge differently than novices?

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Literature Review

This section defines key Pathfinder concepts and addresses the literature relevant to each of the study's research questions. In addition to generating concept maps that represent domain knowledge without the complications associated with expert self-report, Pathfinder generates three measures employed in this study: coherence, relatedness, and similarity. Table 1 describes these measures.

Table 1
Definition, Uses, and Examples of Coherence, Relatedness, and Similarity Scores (adapted from Villachica, 2000)

Measure	Definition	Uses	Examples
Coherence (Theoretical Range = -1.0 to +1.0)	A Pearson Product-Moment correlation indicating the internal consistency of ratings within an individual's or group's set of concept ratings (Interlink, 1996).	A coherence score for an individual's or group's set of concept ratings calculated. This score is compared to that of other individuals.	Student coherence scores obtained prior to instruction are compared to those obtained after instruction to determine if learning occurred.
Relatedness (Theoretical Range = -1.0 to +1.0)	The Pearson Product-Moment correlation between sets of concept ratings (Interlink, 1996).	The comparison of an individual's or group's set of concept ratings to another's.	The proximity matrices of students are correlated with a referent matrix containing the averaged responses of a panel of experts.
Similarity (Theoretical Range = 0 to +1.0)	The proportion of shared links in two concept maps using the same terms. The ratio of shared neighborhoods in two Pathfinder networks (Interlink, 1996).	The Pathfinder networks of an individual or group are compared to those of another.	The Pathfinder networks of students are compared to their instructor's. The resulting similarity scores are used to predict performance on a test.

Coherence and Expertise

Since the knowledge structures of experts are more organized than those of novices, experts in a given domain should possess relatively higher coherence scores. The higher the coherence score, the greater the internal consistency of the concept ratings. Four studies have investigated the relationship between coherence and expertise in different domains. However, results have been uneven, indicating a need for additional replication.

Three of these studies found a correlation between coherence and expertise. In a classroom setting, Housner, Gomez, and Griffey (1993) investigated the extent to which coherence scores and other knowledge structures would predict performance in a physical education preservice course. They found a moderate correlation between coherence and a simulated teaching activity (r = .63). Gaultieri, Fowlkes, and Ricci (1996) investigated the effectiveness of training that eight Navy and Air Force pilots received over a five-day workshop. This training consisted of pre-briefings, simulated missions, and debriefings. The pilots were divided into two teams of four pilots each, with each participants rating concept pairs on the first, third, and fifth days. Results of a repeated measures analysis of variance revealed a statistically significant increase in participants' coherence scores over time ($f2,14 = 11.55$. $p < .001$). In a similar study, Stout, Salas, and Kraiger (1997) studied 12 naval aviator trainees enrolled in a one-day, complex training program addressing aviation teamwork and communication skills. The researchers reported that course attendees earned higher mean coherence scores than a control group who received no training ($t = 2.70$, $p < .01$, $M_{traineees} = .63$, $M_{control} = .26$).

One study did not find a relationship between coherence scores and domain expertise. Dorsey, Campbell, Forste, and Miles (1999) used Pathfinder networks to create concept maps that evaluated relationships generated by 88 computer users and compared them against the scores of four subject matter experts. Their results indicated that coherence scores were not significantly related to any of the concept map scores.

Within the domain of HPT, coherence scores would conceivably be positively correlated with several measures of expertise. Experts in HPT are members of a community of practice that has its roots in academe. As a result, experts can be expected to present at conferences, write articles, and author books. They can be expected to have spent at least 10 years developing their expertise (Ericsson, 1996).

Organization of HPT Domain Knowledge

The organization of HPT domain knowledge can be viewed in terms of existing expert representations of the domain and the extent to which a Pathfinder-generated concept map could supplement these existing models.

Existing expert representations of HPT. Given the depth and breadth of HPT, a variety of experts have authored conceptual and procedural representations of the discipline. Each representation depicts an expert's organization of his or her HPT expertise. Conceptual representations place HPT within theoretical contexts and illustrate the relationships among its components. Procedural representations illustrate the steps comprising an HPT process.

Stolovitch and Keeps (1999) provide both conceptual and procedural representations of HPT. In their conceptual model, the authors depict external and organizational environments that influence internal requirements related to human performance. Once articulated, these requirements trigger behaviors that produce accomplishments, which are subjected to verification. Accomplishments that are aligned with business requirements are accepted; those that are not aligned are subjected to subsequent alteration in behaviors, which change the organization's accomplishments. Their procedural representation of HPT consists of an iterative, 10-step process that begins with the identification of business requirements and concludes with monitoring and maintaining performance interventions. At this point, the process can repeat itself, leading to the identification of new requirements and subsequent interventions.

Addison (2001) provides a conceptual view of HPT in his Performance Consultant HPT Landscape. This representation of the discipline depicts the interaction of two conceptual and two procedural dimensions that comprise the landscape:

1. Levels of the environment, ranging from the worker to society (conceptual);
2. Principles of performance technology (conceptual);
3. Systematic approach, starting with need and ending with evaluate (procedural); and
4. System(s) view point, beginning with conditions and ending with feedback (procedural).

The International Society for Performance Improvement has created its own procedural representation of HPT. This process model focuses on a systematic combination of performance analysis, cause analysis, and intervention selection (ISPI, 2001). The majority of steps comprising the HPT model contain additional conceptual information providing additional detail about a given step.

Pathfinder representations of expertise. In addition to the conceptual and procedural representations used to depict expert's organization of HPT, one can use Pathfinder networks to represent this domain-specific expertise. The end result of Pathfinder analysis is a concept map that depicts a semantic network representing a domain, such as HPT. These concept maps are intended to represent the knowledge structures that humans store in their minds (Jonassen, Beissner, & Yacci, 1993).

Researchers have employed Pathfinder-derived concept maps to study the nature of expertise in some 13 studies and nine different domains, ranging from aircraft combat to programming to electronic troubleshooting to medicine (Villachica, 2000). In a similar vein, Pathfinder-derived concept maps could depict the way in which HPT experts organize their domain knowledge, providing another representation of this complex discipline.

Novice/Expert Differences in the Organization of HPT Knowledge

It is not surprising that novices and experts exhibit different levels of domain-specific performance. A well-established line of research traces the sources of these performance differences to the organization of cognitive structures in memory. De Groot (1978) and Chase and Simon (1973) demonstrated that expertise in chess is partially attributable to the organization of memory. Chess masters possess more highly organized and complex structures in long-term memory than chess experts, who possess more organized and complex structures than non-experts. These differences in domain knowledge allow chess masters to employ a larger visual scan than chess novices (Reingold, Charness, Pomplun, & Stampe, 2001). Similarly, Chi, Feltovich, and Glaser (1981) report that physicists sort physics problems differently than novices, with experts' organizational strategies revealing more sophisticated cognitive structures, based upon their knowledge of the "deep structure" of the domain.

Pathfinder-related studies that address novice/expert differences in domain-specific cognition have found that experts tended to exhibit greater degrees of intragroup agreement than novices. That is, the relatedness, similarity, and coherence scores of experts tended to be more similar than those of novices. For example, Schvaneveldt, Durso, Goldsmith, Breen, and Cooke (1985) conducted a discriminant analysis using Pathfinder measures that successfully predicted novice and expert performance in a fighter pilot task. Schvaneveldt, Durso, and Dearholt (1989) employed Pathfinder-produced concept maps to study differences in the ways in which biology graduate students ("experts") and undergraduate students ("novices") organized their knowledge of biology. Schvaneveldt, Beringer, Lamonica, Tucker, and Nance (2000) used Pathfinder to demonstrate differences in the priorities that novice and experienced commercial aircraft pilots assign to information viewed during the phases of a flight. Thompson (1992) employed Pathfinder-based measures to reveal differences in the organization of domain knowledge among expert, non-expert, and novice nurses.

Given the consistency of these findings, one should expect to find novice-expert differences in the organization of HPT knowledge. That is, the Pathfinder-related measures of an operationally defined set of experts should be more like each other than they are like those of a set of novices.

Methodology

Participants and Procedure

ISPI issued invitations to participate in the study to approximately 4,500 of its 6,000 members (75 percent). ISPI published the invitations on two occasions, the first invitation in its online newsletter ISPI Quick Read. After 14 days, only 38 people had responded to this invitation. ISPI then emailed a second invitation to its members two weeks later. With this invitation, another 103 persons had responded, making a total of 141. Of those, 4 people had submitted duplicate data sets, which were subsequently removed from the study. Of the 137 people who had completed the survey, 73 went on to complete all 435-concept ratings. Thus, the overall response rates to the study were 2 and 1 percent, respectively.

The researchers drafted an initial list of 50 HPT-related concepts based upon a review of the Handbook of HPT (Stolovitch & Keeps, 1999). Acting as the operationally defined referent experts for the study, the ISPI 2000-2001 Board participated in a modified Delphi process that resulted in a final list of 30 HPT concepts that would be employed in the study. ISPI members were invited to participate in the study via two methods. One, a general announcement was published in the ISPI Quick Read newsletter, and second, individual invitations were emailed. The second section of both the ISPI Quick Read article and the email invitation contained an informed consent form. Subjects who agreed to participate in the study indicated their agreement by clicking on a link that directed them to a website used to collect demographic data and concept ratings. In order to maintain confidentiality, all data were aggregated into a single computer file using the computer to assign unique, anonymous participant identification codes. Once subjects had entered their responses into an online dataset, all names were deleted from the file, thereby guaranteeing the anonymity of all participants and protecting subjects against unintentional disclosure outside the experiment.

The website consisted of the several pages, which participants completed in order. After viewing a welcome page that described the purpose of the study, participants viewed instructions about rating HPT concepts. The practice component comprised of the next two pages of the web site. In the first page, participants then viewed a list of practice terms, which appeared next to radio checkboxes. Participants could click next to any term they did not know. In the next page, participants completed a set of practice ratings. The survey component of the web site consisted of a single web page that participants completed to provide information about themselves. The ratings component of the web site consisted of two pages. In the first page, participants viewed the complete list 30 HPT concepts; with the option to check any terms they did not know. In the next page, participants rated up to 345 randomly presented pairs of HPT concepts, checking on the radio buttons comprising a rating scale to assign lower numbers (1-4) to unrelated pairs and higher numbers (6-9) to related pairs. Participants assigned a "5" to concept pairs they did not know or could not rate. The last pages of the web site thanked participants and allowed them to view additional information about the HPT Research Group conducting the study. The concept ratings participants provided were then stored as proximity matrices for subsequent Pathfinder analysis.

Results

Coherence and HPT Expertise

Table 2 summarizes the measures, survey items, number of respondents, means, standard deviations, and standard errors used in the regression analysis of coherence scores.

Table 2

Descriptive Statistics Used in the Regression of Coherence Scores on Measures of HPT Expertise

Measure	Item	Statistics
Coherence scores	Not applicable	N = 73 M = 0.324 SD= 0.153
Years HPT practitioner	How many years have you been a practitioner of human performance technology?	N = 137 M = 11.161 SD = 8.239
Number of juried presentations	How many JURIED presentations relating to HPT have you written or co-written?	N = 137 M = 3.321 SD = 11.758
Number of non-juried presentations	How many NON-JURIED presentations relating to HPT have you written or co-written?	N = 137 M = 4.409 SD = 8.839
Number of juried articles	How many JURIED articles relating to HPT have you written or co-written?	N = 137 M = 0.744 SD = 3.097
Number of non-juried articles	How many NON-JURIED articles relating to HPT have you written or co-written?	N = 137 M = 2.007 SD = 6.026
Number of book chapters	How many book chapters relating to HPT have you written or co-written?	N = 137 M = 0.774 SD = 3.132
Number of books	How many books relating to HPT have you written or co-written?	N = 137 M = 0.197 SD = 1.028

To determine the relationship between Pathfinder coherence scores and other measures of expertise, the researchers employed a multiple linear regression analyses that regressed coherence scores on the number of years as an HPT practitioner, number of juried presentations, number of non-juried presentations, number of juried articles, number of non-juried articles, number of book chapters, and number of books the participant had either written or co-written. To control for Type I error, alpha was set at .05. All variables were entered at once. The multiple linear regression produced statistically significant results (r = .458, p = .026), accounting for 21 percent of the variance in coherence scores. As depicted in Table 3, the only statistically significant independent variable contained in the equation was the number of books the participant had written or co-written. The other independent variables did not reach levels of statistical significance. The magnitude of this correlation is weak, although it approaches the moderate threshold of .5.

Table 3

Regression Analysis Summary for HPT Expertise Variables Predicting Coherence Scores

Variable	**Coherence (n = 73, r^2 = . 0.210)***		
	B	**SE B**	**β**
Years HPT practitioner	0.0006	0.002	0.027
Number of juried presentations	-0.0005	0.007	-0.012
Number of non-juried presentations	-0.0049	0.007	-0.149
Number of juried articles	0.0056	0.029	0.033
Number of non-juried articles	0.0098	0.013	0.126
Number of book chapters	-0.0025	0.016	-0.020
Number of books	0.2747	0.067	0.468*

$p < 0.05$

It should be noted, however, that only 9 of 137 participants who responded to this item on the demographic survey had written a book. Stevens (1992) notes that statistical procedures based upon regression are mathematical maximization procedures may capitalize on chance and artificially increase alpha, especially when the number of subjects is not large relative to the number of variables. Thus, the results obtained in this study may not replicate in another sample.

Organization of HPT Expertise

As a measure of the internal consistency of a participant's concept ratings, coherence scores can be used as an operational indicator of domain expertise (Interlink, 1994). To identify the participants who would act as the expert HPT practitioners in this study, the researchers identified all participants with coherence scores greater than 0.4 (n = 21, M = .4976, SD = .1309) (Schvaneveldt, personal communication, June 23, 1998). The researchers then averaged the concept ratings of these operationally defined experts and subjected the results to Pathfinder analysis, which produced the following concept map. Figure 1 represents the organization of a statistically derived, "averaged expert's" cognitive organization of HPT.

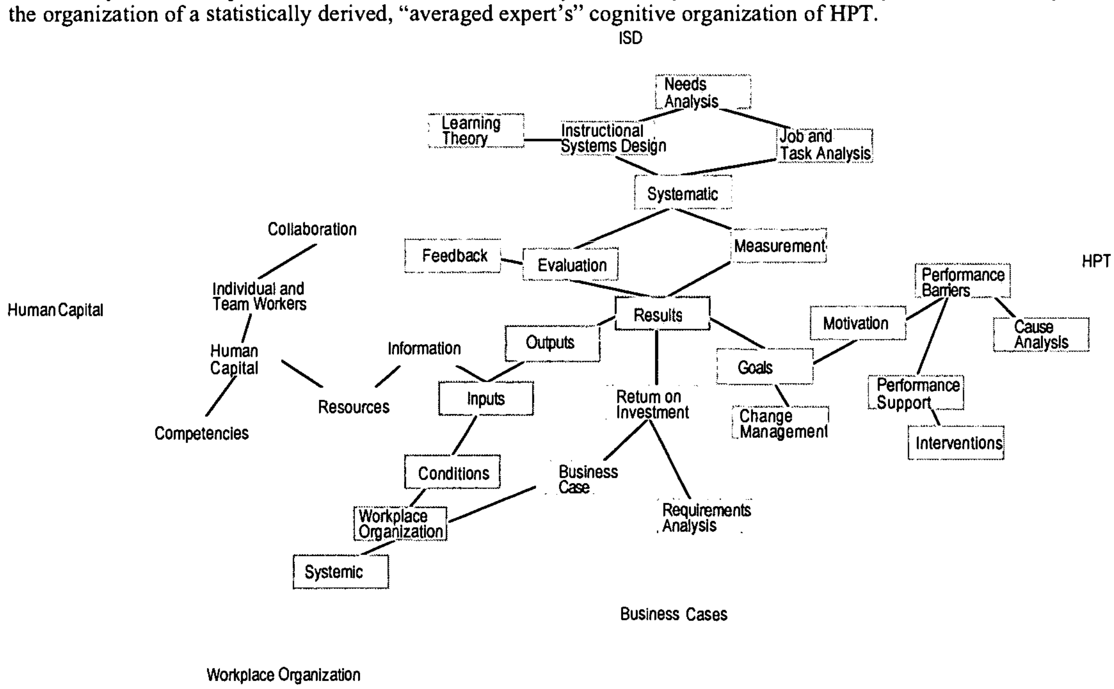

Figure 1. Expert Concept Map

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The key concept in the map is represented by "*results*," which is linked to four other sets of concepts. The *first* set branch of concepts contains the terms "*learning theory*, "*ISD*," "*needs analysis*," "*job and task analysis*," "*systematic*," "*measurement*," "*evaluation*," and "*feedback*." The organization of these concepts indicates that experts employ ISD and its related components to obtain results. The *second* branch of concepts related to "*results*" contains the terms "*goals*, "*change management*," "*motivation*," "*performance barriers*," "*cause analysis*," "*performance support*," and "*interventions*." These terms form the basis of HPT theory and reflect its behavioral roots. The organization of these concepts indicates that experts employ HPT theory to obtain results. A *third* branch of concepts related to "*results*" contains the terms "*Return on Investment*", "*business case*," and "*requirements analysis*." Experts use requirements analysis to build business cases from which they can predict a return on investment that quantifies obtained results. The organization of these items indicates that experts employ business-related measures to obtain results. A *fourth* branch of concepts related to "*results*" is more complex and consists of two separate subsets. The first subset consists of the terms "*outputs*," "*inputs*," "*conditions*, "*work organization*," and "*systemic*." Systemically accounting for workplace organization, experts assess the conditions of performance, their inputs, and their outputs in determining performance results. It is also important to note that "*workplace organization*" is also linked to "*business case*," indicating that experts use the context of the workplace to create such cases. The second subset consists of the terms "*information*," "*resources*," *human capital*, "*competencies*," "*individual and team workers*," and "*collaboration*." The organization of these terms indicates that collaboration among individual and team workers builds human capital, which can be described in terms of competencies. Human capital is linked to resources. Information about resources allows resources to be used as inputs to performance-which ultimately lead to outputs and results.

Novice/Expert Differences in the Organization of HPT Knowledge

To explore differences in the organization of HTP knowledge among an operationally defined set of novices and experts, the researchers employed a median split. In this instance, experts were operationally defined as any participant possessing a coherence score one standard deviation above the mean ($\underline{n}$ = 8, $\underline{M}$ = .1035, $\underline{SD}$ = .0553). Novices were operationally defined as any participant possessing a coherence score one standard deviation below the mean ($\underline{n}$ = 8, $\underline{M}$ = .1353, $\underline{SD}$ = . 0161). Table 4 summarizes means and standard deviations associated with experts' and novices' similarity and relatedness scores.

Table 4
Numbers, Means, and Standard Deviations for Novice and Expert Similarity and Relatedness Scores

Group	**Measure of Knowledge Organization**					
	Similarity Scores			Relatedness Scores		
	N	M	SD	N	M	SD
Expert	8	0.1353	0.0553	7	0.0659	0.0421
Novice	8	0.1035	0.0161	8	0.0322	0.1122

To determine if the similarity and relatedness scores of experts were more similar to each other than they were to novices, the study employed a multivariate analysis of covariance (MANCOVA). Novice/expert designation acted as the independent variable. Similarity and relatedness scores acted as the dependent variables. As coherence scores were used to operationally define groups and represented a source of variation beyond the control of the researchers, they were used as a covariate in the analysis. To control for Type I error, alpha was set to .05.

The results of the MANCOVA indicated that the group effect was statistically significant (Wilks' Lambda = .544, $\underline{f}(1, 14)$ = 4.615, $\underline{p}$ = .035). Eta-squared (1-Wilks' Lambda) revealed that approximately 46 percent of the variance in the linear combination of the dependent variables was associated with group differences. As summarized in Table 5, tests of between-subjects effects revealed that group differences were attributable to similarity scores alone.

Table 5
MANCOVA Results for Similarity and Relatedness Scores as a Function of Group and Coherence

Source	Dependent Variable	df	SS	MS	f
Covariate (Coherence)	Relatedness	1	0.0035	0.0035	.439
	Similarity	1	0.0065	0.0065	5.820*
Group	Relatedness	1	0.0065	0.0065	.816
	Similarity	1	0.0110	0.0110	9.803*
Residual	Relatedness	12	0.0952	0.0079	
	Similarity	12	0.0135	0.0011	
Total	Relatedness	15	.137		
	Similarity	15	.249		

* $\underline{p} < 0.05$

Discussion

Coherence and HPT Expertise

Although the number of years participants had been a HPT practitioner was expected to weakly correlate with participants' coherence scores, it did not. Although the sample exceeded Ericsson's (1996) threshold of ten years to reach expert status in a domain, no correlation with coherence scores or any other measure of expertise was found. Since the number of non-juried/juried presentations and publications are based upon recognition in the field and the results of peer review, it was thought that these indirect measures of HPT expertise would correlate with coherence scores. Although these measures correlated among themselves, they did not correlate with coherence; book production alone correlates with coherence.

Three possible explanations for the significant relationship between coherence scores and authoring an HPT-related book include: 1) desire to create detailed conceptual structures or schemas, 2) tolerance for tedium, and 3) low sample size. The correlation between coherence scores and writing an HPT-related book could be the result of the capacity or desire of an author to develop highly detailed and organized cognitive structures or schemas. Books are representations of schemas, divided into chapters and sections. Perhaps book authors possess such schema, making it more likely that their cognitive maps would correlate with coherence scores.

Another conceivable reason for the correlation between book authorship and coherence scores may be book authors' tolerance for tedious activity. Authoring depends on patience, self-discipline, and a large devotion of time and energy. Authoring also requires one to switch attention between small details and large-picture views frequently. The structure of this study's pair-wise rating activity required the same sort of mental activity for an extended period of time (between 30 minutes and one hour). Perhaps individuals who were able to complete the ratings and stay on task for this time are also individuals who can author books.

Finally, the low sample size employed in the study may have precluded obtaining significant results. In addition to artificially increasing alpha, low sample size may have lacked adequate statistical power to detect otherwise significant relationships between coherence scores and measures of HPT expertise. Replicating this study with a larger sample and modifications to the website to decrease experimental mortality (that is, the number of participants who dropped out of the study between completing the information page and their concepts) could produce less ambiguous findings.

Organization of HPT Expertise

The expert concept map is similar to other expert representations of HPT, suggesting the convergent validity to this finding. The information and resource components of the human capital branch of the concept map roughly correspond to the organizational environment of Stolovitch and Keeps' (1999) conceptual representation of HPT. The business case branch corresponds to their components of business goals/objectives and internal requirements. Where Stolovitch and Keeps focus on accomplishments and their verification, the expert concept map focuses on results. Additional similarities can be found comparing the expert concept map to Stolovitch and Keep's procedural representation of HPT. The business case branch of the concept map addresses Stolovitch and Keeps' steps for identifying business and performance requirements. Likewise, the HPT branch of the concept map addresses the steps "define performance gaps, specify gap factors, and select interventions."

One of the underlying principles of the HPT landscape model (Addison, 2001) is a focus on results and outcomes. The expert concept map also communicates a focus on results, which is the key concept on the map. Sections related to ISD, human capital, business cases, and HPT are linked to obtaining results. The systems and business case portions of the Addison model are similar to the ISD systems and business case branches of the expert concept map. The predictive validity of the expert concept map could be determined by determining the extent to which it predicts performance in HPT. For example, concept ratings could be obtained from previous winners of ISPI awards. These scores could be compared against a control group who did not win such awards. Subsequent statistical analysis could determine the extent to which Pathfinder-derived relatedness, similarity, and coherence scores predicted the award-winners. In addition to providing a unique perspective of HPT as a discipline, practitioners and researchers could employ the concept map in different ways. For practitioners, the expert concept map can assist in the creation of HPT competencies. The different branches of the map could represent the major HPT competencies. The organization of subordinate and related competencies could also be derived from the concept map.

Experienced practitioners could use the concept map as a "mind tool" to introduce new practitioners to HPT. Specifying the nature of the links could help learners construct their knowledge of the discipline (Jonassen, 2000). The similarity measure that Pathfinder derives from the concept map could also be used as an assessment tool for practitioners and researchers alike. As new practitioners gain experience solving increasingly difficult problems in the domain, their similarity scores should increase, indicating that their mental map of HPT is increasingly like those of experienced practitioners. Their development within this community of practice could be modeled statistically, with different stages of practitioner HPT development lending themselves to different learning and other types of performance supporting interventions. If such stages and interventions could be determined, then whole programs could be designed to help novices move along a continuum of HPT expertise, potentially improving the quality of HPT practice while decreasing the time required obtaining expert-like performance.

Novice/Expert Differences in the Organization of HPT Knowledge

The similarity scores of experts are higher than those of novices, indicating that expert concept maps are more like those of other experts than of novices. This finding replicates the results of other studies comparing the organization of expert and novice cognition. Specifically, experts share a greater proportion of the links in their individual concept maps with those of the "averaged expert's" concept map (p. 8) than do novices (14 percent versus 10 percent, respectively). It should be noted, however, that the small sample used in this analysis may not provide replicable results.

Conclusion

While the results obtained in this study are intriguing and suggest potential uses of the expert concept map and related Pathfinder-based measures in HPT, these results are based upon a small sample. Replication with a larger sample is certainly warranted.

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