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Developing and demonstrating knowledge: Ability and non-ability determinants of learning and performance

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ABSTRACT

Ability and non-ability traits were examined as predictors of learning, operationalized as the development of knowledge structure accuracy, and exam performance in a semester-long course. As predicted by investment theories of intellectual development, both cognitive ability and non-ability traits were important determinants of learning and exam performance. Mastery goal orientation (the focus on developing competence) was related to learning, but not exam performance. Conscientiousness was positively related to learning and exam performance. Performance-avoid orientation (a focus on avoiding normative evaluations of incompetence) was negatively related to the development of knowledge structure accuracy, but was positively related to exam performance after accounting for knowledge structure accuracy and cognitive ability — suggesting that wanting to avoid failure may be functional for exam performance, but dysfunctional for learning.

1. Introduction

Investment theories of intelligence consider both cognitive ability and non-ability components in intellectual development, and define learning as the application of cognitive abilities, directed by non-ability traits, toward the development of domain knowledge (Ackerman, 1996; Cattell, 1987). Empirical research has provided support for these theories in finding that both cognitive ability and non-ability traits are important determinants of existing knowledge across a broad range of academic knowledge domains (e.g., Chemistry, Physics, World Literature, Geography; Ackerman, 2000; Ackerman & Rolfhus, 1999) and non-academic domains (e.g., Business, Technology, Health, Financial Issues; Ackerman & Beier, 2006; Ackerman & Rolfhus, 1999; Beier & Ackerman, 2001, 2003). Studies of knowledge acquisition in educational and training environments also identify ability and non-ability traits (motivation, self-regulation, and personality traits such as openness; Colquitt, LePine, & Noe, 2000) as important determinants of learning, although cognitive ability is the most consistent predictor.

The purpose of this study was to examine knowledge acquisition over time within the framework of investment theories of intellectual development. To this end, we examined individual differences in ability and personality and their relation to two indices of learning in a 16-week introductory course in industrial and organizational (I/O) psychology: the development of knowledge structures, and multiple-choice exam performance. Personality traits related to learning and performance were examined: openness to experience and conscientiousness factors from the big-five personality model (Goldberg, 1999), and goal orientation (Dweck, 1986).

Conscientiousness and openness to experience (Goldberg, 1999) are consistently related to performance in school, intellectual interests, and learning; (Ackerman, 2000; Barrick & Mount, 1991; Beier & Ackerman, 2001, 2003). Conscientiousness reflects a person's orientation toward dependability and achievement motivation, which are traits related to performance in achievement situations in educational or professional environments (Barrick & Mount, 1991; Goldberg, 1999). Openness to experience reflects an individual's curiosity and intellectual engagement. Of the big-five personality traits,

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openness is the most consistently related to cognitive ability and learning (Ackerman, 2000; Barrick & Mount, 1991).

Goal orientation (Dweck, 1986) is another important non-ability trait that predicts achievement and learning (Pintrich, 2003). Goal orientation reflects a person's general approach in achievement settings and it has three facets: mastery, performance-approach, and performance-avoid (Elliot & Thrash, 2002). Mastery orientation reflects a focus on the development of competence in a given domain. Those high in mastery goal orientation are focused on learning and use personal standards to evaluate progress. Individuals high in this orientation, for example, would not be afraid to explore and make errors when learning; they would not be concerned that others would evaluate them as less capable because of these errors (Heimbeck, Frese, Sonnentag, & Keith, 2003).

In contrast to mastery orientation, performance orientation reflects a focus on normative evaluations of competence and is further divided into approach and avoidance tendencies. Those high in performance-approach orientation are most interested in demonstrating competence relative to others. Those high in performance-avoid orientation are concerned with avoiding demonstrations of incompetence relative to others. There has been some debate about whether these constructs represent different facets or different ends of the performance orientation continuum: theory and empirical data suggest that they are indeed distinct facets (DeShon & Gillespie, 2005). Research shows that the tendency to want to show competence (performance-approach orientation) is generally positively related to performance. The tendency to avoid demonstrations of incompetence (performance-avoid orientation) is thought to introduce anxiety in learning situations, which detracts from performance (Payne, Youngcourt, & Beaubien, 2007).

Mastery goal orientation has been identified as the most important of the goal orientation traits for learning (e.g., Dweck, 1986): those high in this trait have higher self-efficacy for learning and develop effective learning strategies (Payne et al., 2007). However, research on the relation between mastery goal orientation and performance in learning environments has been somewhat inconsistent, with some studies reporting no relationship (DeShon & Gillespie, 2005; Payne et al., 2007). Similarly, research on performance orientation has been mixed with some studies showing expected relations between performance-avoid and performance in learning contexts (negatively related) and performance-approach and performance in learning contexts (positively related; Chen, Gully, Whiteman, & Kilcullen, 2000; Payne et al., 2007). Other studies do not show these relations, however (DeShon & Gillespie, 2005). One reason for the inconsistency in these findings may be that the performance outcomes used in many studies of learning are end-of-course assessments, such as exams (Chen et al., 2000). Course exams require a focus on performance. As such, the desire to demonstrate competence and avoid demonstrations of incompetence is functional in this context.

In addition to the normative-performance component of exams, many exams (especially multiple choice) are deficient in that they do not capture higher-order learning or understanding. During instructive experiences, trainees learn both declarative knowledge and about the associations between concepts (Goldsmith & Kraiger, 1997). Learners begin to develop an increasingly organized, meaningful, and accurate understanding of a domain, or knowledge structure, which allows them to retrieve and generalize their knowledge. Over the course of instruction, it is hoped that an individual's knowledge structure will more closely resemble the actual structure of that domain.

1.1. Knowledge structures

Knowledge structures (KS), also known as mental models, schemata, and cognitive maps, are representations of the organization of knowledge in a domain (Goldsmith & Kraiger, 1997). Knowledge structures are generally obtained by measuring the interrelation of concepts, ideas, and rules within that domain (Davis, Curtis, & Tschetter, 2003). Multiple methods exist for KS measurement, but many rely on participants possessing conscious access to their mental processes and structures. An effective alternative that does not require conscious recall of underlying schema involves asking participants to judge the relatedness of pairs of concepts in a given domain. These numeric ratings of relatedness between concepts are inputted into a network scaling algorithm in order to elicit the underlying knowledge structure. Pathfinder (Schvaneveldt, 1990) is one such method. Pathfinder converts concept relatedness judgments into a graphical representation of a knowledge structure and produces a quantitative index of the similarity between two structures. In Pathfinder, each concept in a domain is represented as a node in a network, and each link between nodes has a weight, determined by the distance between the two concepts. Pathfinder first links all of the concepts by assigning a weight to each link in the network. The Pathfinder algorithm then systematically removes direct links if there is a shorter indirect route between two concepts. The resulting network represents the psychological proximity of concepts. Pathfinder also compares two networks to calculate a similarity metric, representing a ratio based on the number of links the two networks have in common divided by the number of links in either network.

Similarity scores range from zero to one, where zero means the networks share no links, and one means the networks are identical. This similarity index can be used as an indicator of learning, when a student's knowledge structures are compared to an expert referent structure (e.g., course instructor). This comparison enables measurement of the accuracy of a learner's knowledge structure. Because KS accuracy ratings are a comparison of the expert and learner for all links in the network, these values are typically small in magnitude, especially when a student's complete mastery of a domain is not expected over the course of instruction. For example, the KS accuracy values ranged from .14 to .21 for an introduction to psychology course (Gonzalvo, Cañas, & Bajo, 1994).

Research conducted using Pathfinder in both educational and occupational settings has shown that Pathfinder successfully captured meaningful differences between expert and novice fighter pilots during flight simulator training (Schvaneveldt et al., 1985), and KS accuracy predicted retention and transfer in trainees learning a complex video game (Day, Arthur, & Gettman, 2001). Furthermore, KS accuracy fully mediated the relation between a training intervention and