Sandra Bley
Institute for Human Resources and Education
Ludwig-Maximilians University Munich

Characterizing and Diagnosing Complex Professional Competencies by Using CDM – An example of Intrapreneurship

Abstract:
Caused by an increasing demand of skilled professionals there is a growing interest in objective and standardized diagnosing instruments for professional competences. This paper describes the development and evaluation of a technology-based cognitive diagnostic assessment for measuring intrapreneurship. The sample includes N=919 trainees at the end of their apprenticeship in business and commerce. Evaluation criteria like model and item fit values show overall satisfactory results. We analyze and interpret the identified groups of different intrapreneurship-profiles with regard to substantial findings in the domain of intrapreneurship.

Keywords: intrapreneurship, innovative behavior, cognitive diagnosis models, formative assessment

Introduction and theoretical background

There is an increasing claim to educate "new" skills (Mayer & Solga 2008, pp. 2–3), which become necessary as a consequences of life-long learning challenges and a labor market characterized by uncertainties. Within this study we focusing on the new skill "intrapreneurship" as the ability of innovative thinking and acting in challenging business situations (Weber et al., 2015).
Cognitive Diagnostic Assessments (CDA) in conjunction with Cognitive Diagnostic Models (CDM) provide the potential of diagnostic feedback in the form of learner classification with respect to a set of finer grained sub-competencies (so-called skills) underlying a gross competency. The underlying assumption of CDA/CDM is that a learner only shows competent behavior in a domain if s/he is able to use the necessary skills. For example, verbal protocols in the context of intrapreneurship showed that a trainee requested to develop a GANTT chart masters the task if s/he is able master the skills "arrange aspects in sequences", "use domain-specific terms and procure information" and "use domain-specific tools". On the basis of a meticulous domain analysis (Weber et al., 2014) we identified the 7 intrapreneurship skills given in Table 1.

Skill	Skill description
PERCEV	Perceive challenges, disturbances and opportunities
ANALY	Analyze situations
IDEA	Create ideas
SEQU	Arrange aspects in sequences
INFO	Use domain-specific terms/techniques and procure information
TOOL	Use domain-specific tools
DECID	Make reasoned decisions and defend them

Table 1: Description of the 7 diagnosable intrapreneurship skills.

For the development of the CDA for intrapreneurship we followed the process of reasoning from evidence (Pellegrino et al., 2001) and the evidence-centered design approach (Mislevy & Risconscente, 2006) by considering demands of validity (e.g. Weber, et al. 2015). Besides the selection of an appropriate CDM (George, et al. accepted), the a priori definition of the skill-item-interactions (so-called Q-matrix) is necessary. In conducting a separate triangulation study, we paid particular attention on that developmental step (Bley, 2017).

Research question
In this paper we focus (1.) on quality criteria of the developed CDA and (2.) on the analysis and interpretation of frequently possessed combinations of intrapreneurship skills (so-called skill classes). These skill classes are obtained by the CDM analysis and build an empirical basis for understanding learning in the domain of intrapreneurship.

Methodology
Data are obtained from the main study of the ASCOT project (Weber et al., 2015), which was hold as a one-shot design. A German national sample of N=919 trainees at the end of their apprenticeship in business and commerce (industrial clerks) processes within a 4-hour survey – among other instruments – 22 technology-based authentic intrapreneurship tasks. For evaluation we choose the DINA model (Haertel, 1989). The DINA model was estimated and evaluated with the R (R Core Team, 2015) package CDM (George, et al., 2016). Following the approach of George and Robitzsch (2015), the model fit was assessed.

Results
(1.) The CDM shows an accurate overall model fit (SRMSR = .0464). With a RMSEA smaller than .05 15 of the 22 items provide accurate an item fit (the other 7 items have a moderate fit). The mean item difficulty is .505. Regarding the item discrimination 3 of the 22 items need an improvement (for these items the IDI is smaller than .3). The abnormalities are currently under revision.
(2.) The DINA model identifies 14 skill classes having a higher occurrence probability than .1. The range of these 14 skill class probabilities is high, varying between .1 for the skill class with students possessing ANALY and INFO and .48 for the skill class with trainees possessing all 7 skills. 7% of the trainees are assigned to the skill class containing none of skills. All skill classes with probabilities larger than .25 are listed in Table 2

Group number	Frequencies	Skill description
1	48,59%	*all skills*
2	6,98%	*no skill*
3	6,92%	SEQU INFO TOOL
4	5,46%	PERC ANALY IDEA SEQU INFO TOOL
5	4,22%	PERC ANALY IDEA SEQU
6	4,08%	PERC ANALY INFO TOOL
7	3,70%	IDEA SEQU INFO TOOL
8	3,63%	IDEA SEQU TOOL
9	2,50%	SEQU

Table 2: the 9 most frequent skill classes

Furthermore, the analysis shows that trainees are frequently able to “arrange aspects in sequences” (SEQU) or to “use domain-specific terms/techniques and procure information” (INFO). However, they more often fail in skills as “make reasoned decisions and defend them” (DEFEND) or “create ideas” (IDEA). These outcomes are in line with preliminary studies about learning and learning acquisition in the field of intrapreneurship (Weber et al., 2015).

Theoretical and practical significance
Results show that, from a statistical point of view, we succeeded in developing a CDA for measuring the professional competence of intrapreneurship. The high amount of trainees belonging to group 1 (Table 1) illustrates how well trainees at the end of their apprenticeship perform innovative thinking and acting processes in challenging business situations. For more practical significance details see Bley George (2017). In a next step the presented findings and interpretation have to be verified and extended. A large opportunity lies in the replication of the analysis with a longitudinal sample with two measurement points (one in the middle and one in the end of the apprenticeship).

References

Bley, S. (2017). Developing and validating a technology-based diagnostic assessment using the evidence-centered game design approach – An example of intrapreneurship competence. *Empirical Research in Vocational Education and Training, 9*(6), 1-32.

Bley, S. & George A. C. (2017). Kognitive Diagnosemodelle zur Begleitung individualisierter Lehr- und Lernprozesse: Neue Möglichkeiten aus einem alternativen Ansatz? *Zeitschrift für Berufs- und Wirtschaftspädagogik, 113*(1), 56-85.

George, A.C., Bley, S. & Pellegrino, J. (accepted) Characetrizing and Diagnosing Complex Professional Competencies – An example of Intrapreneurship. *Educational Measurement: Issues and Practices.*

George, A.C., & Robitzsch, A. (2015). Cognitive Diagnosis Models in R: A Didactic. *The Quantitative Methods for Psychology*, 11(3), 189-205.

George, A. C., Robitzsch, A., Kiefer, T., Groß, J., & Ünlü, A. (2016). The R Package CDM for cognitive diagnosis modeling. *Journal of Statistical Software, 74*(2), 1–24.

Haertel, E. H. (1989). Using restricted latent class models to map the skill structure of achievement items. *Journal of Educational Measurement, 26*, 301–323.

Mislevy, R. J., & Risconscente, M. M. (2006). Evidenced-centered assessment design: Layers, concepts and terminology. In S. M. Downing & T. M. Haladyna (Eds.), *Handbook of test development* (pp. 61–90). Mahwah, NJ: Erlbaum.

Mayer, K. U., & Solga, H. (Eds.). (2008). *Skill formation: Interdisciplinary and Cross-National perspectives*. Cambridge: Cambridge University Press.

Pellegrino, J. W., Chudowsky, N., & Glaser, R. (2001). *Knowing what students know: The science and design of educational assessment*: National Academy Press.

R Core Team (2015*). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing.* Vienna, Austria.

Weber, S., Wiethe-Körprich, M., Bley, S., Weiß, C., Draxler, C., & Gürer, C. (2016). Der Projektverbund CoBALIT: Large Scale-Assessments in der kaufmännischen Berufsbildung - Intrapreneurship (CoBALIT). In K. Beck, M. Landenberger, & F. Oser (Eds.), *Technologiebasierte Kompetenzmessung in der beruflichen Bildung. Resultate aus dem Forschungsprogramm ASCOT* (S. 75-92). Bielefeld: Bertelsmann.