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Differentiation of the Family Resemblance Approach to Nature of Science

Freie Universität Berlin

Theoretical Background & Research Question

Family Resemblance Approach (FRA) to NOS

Fig. 1. FRA-wheel (Erduran & Dagher, 2014; Irzik & Nola, 2011, 2014)

Research aim:
Development of a differentiated NOS model

Research question: Which subcategories of the 11 FRA categories can be identified by analyzing biology school textbooks ?

Methods

Sample: Biology school textbooks (*N*=7)
Chapters: Introduction, cell biology, genetics, evolution

Analysis procedure: content structuring analysis (Mayring, 2015) including deductive coding: 11 FRA categories (Erduran & Dagher, 2014)

Considerations of quality criteria
Consensual coding
Analyzing overlaps between subcategories (Spendrin, 2019)
Discussions with experts (*N*=8)

Findings

Rater-agreements: Cohen's Kappa ($\kappa_{intrarater}$ = .95; $\kappa_{interrater}$ = .80)

Tab. 1. Cognitive-epistemic system of science (32 subcategories)

(1) Cognitive-epistemic Aims and Values			
(a) Objectivity	(d) Scientific Questions	(f) Empirical Adequacy	
(b) Testability		(g) Variety of Methods	
(c) Novelty	(e) Alternative Ideas		
(2) Scientific Practices			
Practices:	Work Techniques:	Documentation:	
(a) Observing	(f) Chemical and Physical Techniques	(i) Protocolling	
(b) Investigating		(j) Drawing	
(c) Experimenting	(g) Mathematization	(k) Taking Photographs	
(d) Comparing and Classifying	(h) Preparation	(l) Constructing Diagrams	
(e) Modeling			
(3) Reasoning			
(a) Hypothetical-deductive Approach		(c) Deductive Reasoning	
(b) Inductive Reasoning		(d) Abductive Reasoning	
(4) Methodological Rules			
(a) Rejection or Change of Theoretical Constructs		(d) Choice of Research Object	
(b) Conduction of Controls		(e) Avoiding Ad-hoc Changes of Theoretical Constructs	
(c) Choice of Sample Size			
(5) Knowledge			
(a) Hypotheses	(b) Theories	(c) Models	(d) Rules

Tab. 2. Social-institutional system of science (23 subcategories)

(6) Professional Activities	
(a) Publishing Findings	(c) Undertaking Research Trips
(b) Evaluating Research Quality	(d) Receiving Awards and Prizes
(7) Scientific Ethos	
(a) Respect of Research Objects	(d) Confidentiality
(b) Respect for the Environment	(e) Communalism
(c) Protection of Human Subjects	(f) Legality
(8) Social Utility	
(a) Human Health	(c) Police Investigations
(b) Nature Conservation	
(9) Social Organizations and Interactions	
(a) Teamwork	(b) Social Organization of Institutions
(10) Power Structures	
(a) Scientific Community	(d) Science and Society
(b) Science and Policy	(e) Interplay of Science with 'Race'
(c) Science and Religion	
(11) Economics of Science	
(a) Application and Transmission	(c) Financial Support
(b) Commodification and Commercialization	

Subcategory Objectivity (Tab. 1; 1a)
Scientific research is guided by cognitive-epistemic aims and values concerning the achievement of objectively gained knowledge.

Anchor example
"Science enhances knowledge by gaining objective data." (Weber, 2016, p. 14)

Subcategory Publishing Findings (Tab. 2; 6a)
Besides other scientific practices, scientists are publishing.

Anchor example
"In 1859, the Englishman Charles Darwin (1809-1882) published his book 'On the Origin of Species'." (Leienbach, 2016 , p. 257)

Discussion

Textbooks are appropriate to detect distinct NOS contents for each of the 11 FRA categories (cf. BouJaoude et al., 2017; McDonald, 2017; Park et al., 2019)

Content related overlaps of subcategories confirm the FRA structure as "interactive with porous boundaries" (Erduran & Dagher, 2014, p. 143; cf. Spendrin, 2019)

Modifications of 11 FRA categories are assumed to lead to higher discriminatory power (Schreier, 2012, 2014), e.g., by renaming "Methods" into (3) "Reasoning" and by separating it from (4) "Methodological rules" (Tab. 1; cf. Erduran & Dagher, 2014)

High amount of implicit NOS representations is assumed (e.g., anchor example of subcategory 6a) (cf. Abd-El-Khalick et al., 2017; McDonald, 2017; Park et al., 2019)

Outlook

Keyword analysis: Identifying further content in other chapters of the textbooks (cf. Kaya & Erduran, 2016)

Discrimination of implicit and explicit contents (cf. Abd-El-Khalick et al., 2008, 2017)

Interview study with experts (*N*=33) on discipline specificity of the subcategories (Reutlinger et al., 2019; Rosenberg, 2008)

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References

Abd-El-Khalick, F., Waters, M., & Le, A. (2008). Representations of nature of science in high school chemistry textbooks over the past four decades. *Journal of Research in Science Teaching*, *45*(7), 835–855. https://doi.org/10.4324/9781315650524-6

Abd-El-Khalick, F., Myers, J. Y., Summers, R., Brunner, J., Waight, N., Wahbeh, N., … Belarmino, J. (2017). A longitudinal analysis of the extent and manner of representations of nature of science in U.S. high school biology and physics textbooks. *Journal of Research in Science Teaching*, *54*(1), 82–120. https://doi.org/10.1002/tea.21339

BouJaoude, S., Dagher, Z. R., & Refai, S. (2017). The Portrayal of Nature of Science in Lebanese Ninth Grade Science Textbooks. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 79–97). New York: Routledge. https://doi.org/10.4324/9781315650524-4

Erduran, S., & Dagher, Z. R. (2014). *Reconceptualizing the nature of science for science education. Scientific knowledge, practices and other family categories.* Dordrecht: Springer.

Irzik, G., & Nola, R. (2011). A family resemblance approach to the nature of science for science education. *Science & Education, 20(7-8)*, 591–607. https://doi.org/10.1007/s11191-010-9293-4

Irzik, G., & Nola, R. (2014). New directions for nature of science research. In M. R. Matthews (Eds.), *International Handbook of Research in History, Philosophy and Science Teaching* (pp. 999–1021). Dordrecht: Springer. https://doi.org/10.1007/978-94-007-7654-8_30

Kaya, E., & Erduran, S. (2016). From FRA to RFN, or how the family resemblance approach can be transformed for science curriculum analysis on nature of science. *Science & Education, 25*(9-10), 1115–1133. https://doi.org/10.1007/s11191-016-9861-3

Leienbach, K.-W. (Ed.) (2016). *Biosphäre. Band 7-9 Gymnasium Nordrhein-Westfalen. [Biosphere. Edition for classes 7-9 of secondary school in Nordrhein-Westfalen.]* Berlin: Cornelsen.

Mayring, P. (2015). *Qualitative content analysis: theoretical foundation, basic procedures and software solution.* Klagenfurt. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173

McDonald, C. V. (2017). Exploring representations of nature of science in Australian junior secondary school science textbooks. A case study of genetics. In C. V. McDonald & F. Abd-El-Khalick (Eds.), *Representations of nature of science in school science textbooks* (pp. 98–117). New York: Routledge. https://doi.org/10.4324/9781315650524-5

Park, W., Yang, S., & Song, J. (2019). When modern physics meets nature of science. The representation of nature of science in general relativity in new Korean physics textbooks. *Science & Education, 28*(9-10), 1055–1083. https://doi.org/10.1007/s11191-019-00075-9

Reutlinger, A., Schurz, G., & Hüttemann, A. (2019). Ceteris Paribus Laws. In E. N. Zalta (Ed.), *The Stanford Encyclopedia of Philosophy*. Stanford University, Received from https://plato.stanford.edu/entries/ceteris-paribus/

Rosenberg, A. (2008). Biology. In S. Psillos & M. Curd (Eds.), *The Routledge companion to philosophy of science* (pp. 511–519). London: Routledge.

Schreier, M. (2012). *Qualitative content analysis in practice.* Los Angeles, CA: Sage.

Schreier, M. (2014). Varianten qualitativer Inhaltsanalyse: Ein Wegweiser im Dickicht der Begrifflichkeiten. [Ways of doing qualitative content analysis: disentangling terms and terminologies]. *Forum: Qualitative Social Research, 15*(1), 59 para. https://doi.org/10.17169/fqs-15.1.2043

Spendrin, K. (2019). Qualitative Inhaltsanalyse in der Erforschung von Kompetenzanforderungen: ein Forschungsbeispiel zur Analyse von Anforderungssituationen didaktischen Handelns [Qualitative content analysis in research of qualification requirements. An example of the analysis of situational demands in didactics*]. Forum Qualitative Sozialforschung, 20*(3), 14 para. https://doi.org/10.17169/fqs-20.3.3351

Weber U. (Ed.). (2016). *Biologie Oberstufe SII. Gesamtband. [Biology senior level. Complete volume.]* Berlin: Cornelsen.

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