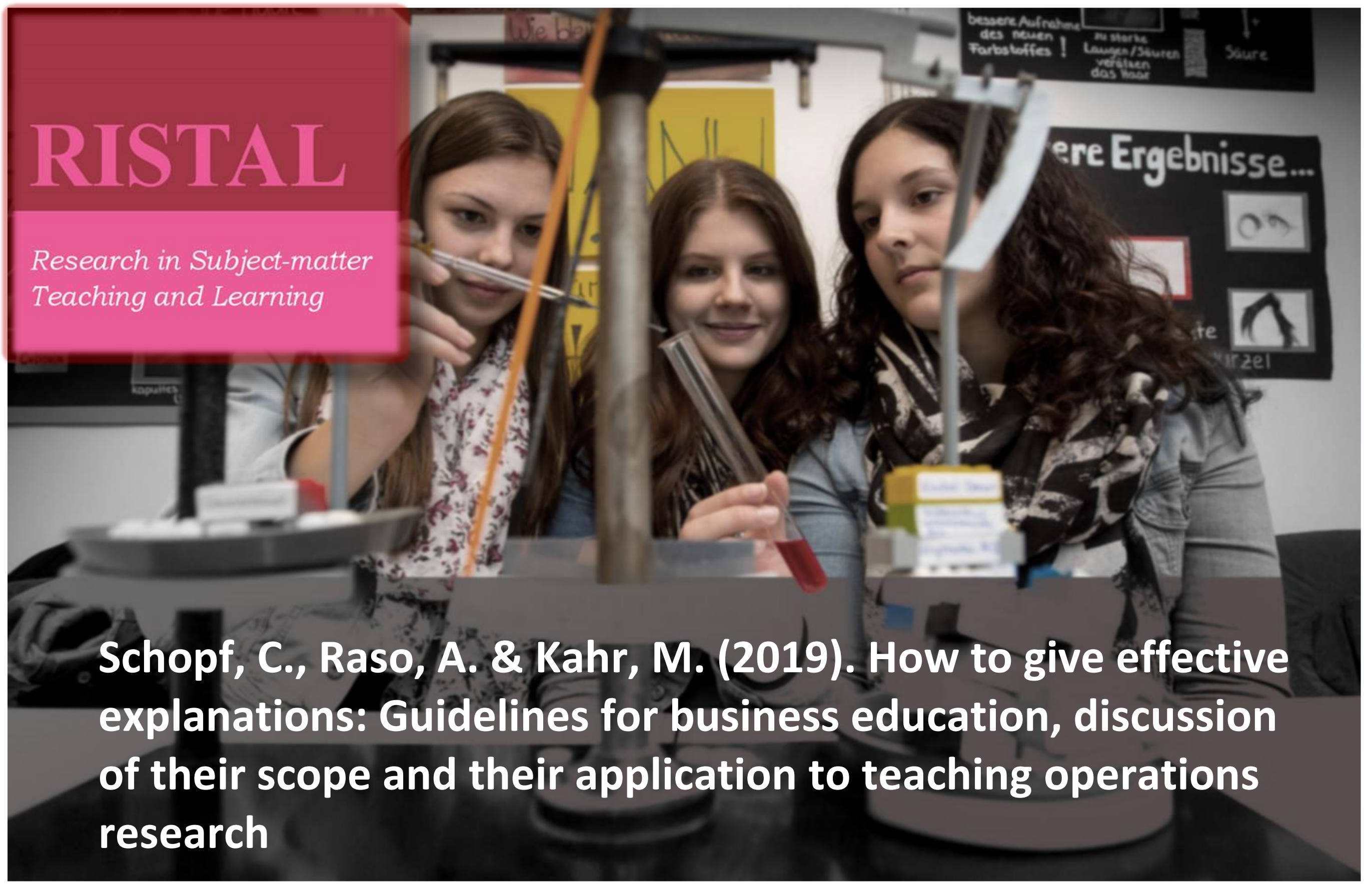

Schopf, C., Raso, A. & Kahr, M. (2019). How to give effective explanations: Guidelines for business education, discussion of their scope and their application to teaching operations research

RISTAL 2 / 2019

Research in Subject-matter Teaching and Learning

Citation:
Schopf, C., Raso, A. & Kahr, M. (2019). How to give effective explanations: Guidelines for business education, discussion of their scope and their application to teaching operations research. RISTAL, 2, 32–50.

DOI: https://doi.org/10.23770/suffix

ISSN 1863-0502-pending

RISTAL. Research in Subject-matter Teaching and Learning 2 (2019), pp. 32–50

How to give effective explanations: guidelines for business education, discussion of their scope and their application to teaching operations research

Christiane Schopf, Andrea Raso & Michael Kahr

Abstract

Giving effective instructional explanations is one of the most important teacher competences. Recent didactic literature provides, however, little insight on teacher explanations. In our previous work we developed guidelines for designing comprehensible explanations in the field of business (teacher) education, which are along general lines transferable to other subject areas and target audiences. In this article, we first compare our guidelines to the state of research in general and mathematics didactics. We then investigate their applicability to teaching operations research at university level, based on interviews with professors of the international operations research community.

Keywords

instructional explanations, comprehensibility, general didactics, business didactics, mathematics didactics, teaching operations research

1 Motivation, contribution and outline

It is widely acknowledged that instructional explanations play a crucial role for students' learning; thus, explaining is one of the most important teacher competences (e.g. Inoue, 2009, p. 47; Odora, 2014, p. 71; Treagust & Harrison, 2000, p. 1157; Wittwer & Renkl, 2008, p. 51). Further evidence for this importance is given by several empirical studies which document the positive effects of clear explanations on students' motivation and achievement; cf. Hattie (2009, p. 200f); Hines, Cruickshank, and Kennedy (1985); Perry (2000); Wilson and Mant (2011). Investigations regarding the design of teacher explanations have, however, been neglected for decades in (subject-matter) educational research in favour of constructivist teaching approaches (Geelan, 2012, p. 987; Schilcher et al., 2017, p. 444; Wittwer & Renkl, 2008, p. 49). Hence, there are only a few guidelines that assist (prospective) teachers in acquiring explanatory competence[1].

As the latter observation holds true especially for the field of business (teacher) education, we elaborated such guidelines for this domain. Based on interviews with professors and senior lecturers from the Institute for Business Education at Vienna University of Economics and Business (WU) and on a document analysis, we developed the so-called "Heuristic for Comprehensible Explaining in Business Education" (HCEBE) (see Schopf &

[1] Note that, in order to give effective explanations, teachers need a specific form of professional knowledge, that is, pedagogical content knowledge as an integration of content knowledge and general pedagogical knowledge (Shulman, 1986, p. 9; König et al., 2016, p. 321).

DOI: https://doi.org/10.23770/suffix

Zwischenbrugger, 2015a and 2015b). As we are convinced that the design of effective explanations in detail is domain or even subject-specific (see also Leinhardt, 2001, p. 344), the elements and attributes of the heuristic were tuned specifically for the domain of business education, which comprises the subjects of business administration, accounting, economics and business informatics, the primary target audience being business college students[2].

Nevertheless, we assume that on an abstract level, the HCEBE is quite generic and, thus, transferable to other subject areas and target audiences. This assumption is supported by the fact that the elements and attributes of the HCEBE can be related to findings from general didactic literature. The latter observation has prompted us to investigate the applicability of the HCEBE in another specific subject. We chose operations research for the following reasons: (i) operations research, which aims at providing decision support based on quantitative methods, is a hybrid discipline with strong connections to business administration as well as (applied) mathematics and, is thus a different but related subject; (ii) operations research is typically taught at university level in an international environment, which gives us the opportunity to involve a different target audience and to significantly broaden our perspective; (iii) operations research is an area in which didactic literature is very scarce – more specifically the available literature mainly focuses on the instruction of specific techniques (or optimization problems), while generic aspects of instruction are neglected.

Hence, this paper investigates to what extent the HCEBE is transferable to other educational contexts, especially to teaching operations research at university level in an international environment. In Section 2 we define our understanding of effective instructional explanations and review the state of the relevant research focusing on general didactics, mathematics didactics as the most adequate approximation for operations research, and business didactics. Moreover, the HCEBE is presented in detail, as it is the basis for this study and has not yet been published in English. In Section 3 we discuss the scope of the HCEBE and provide a comparison to the previously reviewed literature. In Section 4 we present the results of an interview study with professors from the international operations research community to analyse the applicability of our heuristic in that field. In Section 5 we draw conclusions and discuss implications.

2 Effective instructional explanations – definition and state of the research

2.1 Definition

Instructional explanations are designed to "communicate some portion of the subject-matter to others, the learners" (Leinhardt, 2001, p. 340). The objective is that the learn-

[2] Austrian business colleges are full-time schools at the secondary level providing general as well as vocational education.

DOI: https://doi.org/10.23770/suffix

ers know, understand or are able to do something (Schmidt-Thieme, 2009, p. 126). Indeed, an explanation can only facilitate but not ensure that this objective is achieved, because imparted information must be processed actively by the learners (Ehlich, 2009). Thus, explaining has to be seen as "an attempt to provide understanding" (Brown, 2006, p. 196).

Although the term "instructional explanation" can also refer to peer explanations, co-constructed explanations or written explanations, we will use it as a synonym for oral teacher explanations throughout this article. Moreover, we define an explanation to be "effective" if it is comprehensible and motivating for its target audience.

2.2 State of the research in general didactics

In search of guidelines for the design of effective instructional explanations, text comprehensibility research delivers some fundamental findings the transferability of which to explanations seems plausible: (i) The psychological approach (see e.g. Christmann & Groeben, 1999; Langer, Schulz von Thun, & Tausch, 2011) reveals important clues on what to pay attention to when designing explanations, especially with regard to language (e.g. simple words and sentences) and content (e.g. well-structured, focused on the essential). (ii) The cognitive approach (Ballstaedt, 1997; Biere, 1989) finds that comprehension is only possible if the new information can be connected to existing knowledge structures.

Specific research on oral teacher explanations can primarily be found in the context of teacher effectiveness research that was popular in the United States (see e.g. Bligh, 1974; Duffy et al., 1986; Gage & Berliner, 1984; Roehler & Duffy, 1986). This branch of research is, indeed, being criticized for the lack of theoretical background with regard to cognitive processes. Nonetheless, it provides empirically well-documented practical guidelines. The most significant results of teacher effectiveness research can be summarized as follows: be prepared, ensure clarity and goals, structure your lecture well, give orientation at the beginning of an explanation, hint at meaning, use explanatory connectors, support comprehension with accurate examples, analogies or visual aids, limit linguistic complexity, avoid vagueness, be dynamic and enthusiastic, as well as repeat explanations after elaborations (Kiel, 1999, p. 134ff).

In further general didactic works that summarize theoretical considerations and previous empirical results on teacher explanations (see e.g. Brown, 2006, p. 205ff; MacDonald, 1991, p. 143ff; Wellenreuther, 2015, p. 167ff; Wittwer & Renkl, 2008, p. 51ff; Zwozdiak-Myers & Capel, 2009) as well as on lectures or informative presentations (see e.g. Brophy & Good, 1986, p. 362; deWinstanley & Bjork, 2002; Gudjons, 2007, p. 167ff; Helmke, 2007, p. 45), some core quality characteristics consistently emerge. These are: reference to previous knowledge, objectives and structures that are clear and visible to learners, illustration of the use of the knowledge, posing a problem/question, examples and general rules, visual aids, simple language, appropriate pace/redundancy, humour and enthusiasm.

DOI: https://doi.org/10.23770/suffix

2.3 State of the research in mathematics didactics

In the literature on explanations in mathematics didactics, explaining is seen as a medium for learning mathematical content, and simultaneously, as a learning objective (Erath & Prediger, 2015, p. 33; Schmidt-Thieme, 2009, p. 129f). Thus, the focus is more on students' explanations than on teacher explanations. In most cases, general quality criteria for mathematical explanations in classroom discourse are defined.

The differentiation of what-, how- and why-explanations is very common in literature (Kiel, Meyer, & Müller-Hill, 2015, p. 3; Schmidt-Thieme, 2009, p. 126; Wagner & Wörn, 2011, p. 22). Wagner and Wörn (2011, p. 23ff) describe explanations in four phases: stimulus, initiation, process and coda. Erath and Prediger (2015) conceptualise the process of explaining from an interactionist perspective as navigation through an epistemic matrix, which combines logical levels and epistemic modes, and deduce strategies for effective moderation. Criteria for effective explaining are derived from different sources: Röhrl and Krauss (2017) interviewed teachers and subject didactic experts, Fahse and Linnemann (2015) asked students to evaluate peer explanations, Roberts (1999) had students answer a questionnaire, and Leinhardt (1987) analysed a series of expert teacher explanations; Drollinger-Vetter (2011), Charalambous, Hill, and Ball (2011), Forman and Rash (2015) as well as Kiel et al. (2015) give recommendations based on theoretical considerations and practical experiences. The most comprehensive and detailed presentation of guidelines can be found in Wagner and Wörn's (2011) book on how to learn to explain. Therein, criteria of effective explanations are divided into four categories: (i) Structural criteria concern the components and sequence of an explanation. An overview should be given at the beginning of an explanation, the explanandum should be defined precisely, the steps of the explanation should follow a logical order, and the explanation should concentrate on the key points. (ii) Concerning the content of an explanation, all elements that are necessary for understanding need to be addressed, adequate visualisations should be selected, and the argumentation should be stringent and factually correct. (iii) An explanation should address any lack of understanding, use appropriate language and visualisations and alternative explanations should be available. (iv) Additional criteria concern, e.g., involving the audience, giving feedback, and using suitable language/body language.

2.4 State of the research in business didactics

Standard works of business didactics only give general advice on the design of lectures without going into detail concerning the act of explaining. For instance, Euler and Hahn (2007, p. 419) as well as Kaiser and Kaminski (2012, p. 109) simply reference the criteria of text comprehensibility. Dubs (2009, p. 186) and Wilbers (2014, p. 135) provide more extensive checklists including the following aspects: clear structure, advance organizer and summary, connections to students' previous knowledge, visualisation, appropriate language/body language, and appropriate length.

There is only a limited amount of previous work that deals with the design of lectures and instructional explanations in detail. For instance, Schneider (1995) developed a guideline for informative lectures later referred to as "Viennese Model of Comprehensibility". In a nutshell, this model implies that the previous knowledge of the target audience needs to be considered, and clearly structured general rules as well as appropriate illustrative examples should be balanced. Oral presentations should also be supported by visual aids. Furthermore, Schneider explicates that a certain level of redundancy is beneficial, sentences should be short and simple, and that unknown terms need to be explained.

Based on Schneider's model Geissler, Kögler, and Pachlinger (2013) analysed the technique of explaining. They state that explainers have to perform three mental actions when preparing an explanation: (i) The keys need to be identified by answering the questions: "What is it about?", "Why is it important?", "How can it be described?" and "What is the general rule?"; (ii) Concrete examples that illustrate the general rule need to be found; (iii) The previous knowledge of the learners and the desired scope of the explanation have to be judged. In the explanatory talk itself, explainers should use short and simple sentences, avoid any vagueness, adapt to the learners' language level, and explain unknown (technical) terms. Visual aids should be used if possible. Finally, explainers should verify the learners' understanding.

Aff (2016, p. 168ff) proposed a comprehensive model for the explanation of economic concepts comprising four dimensions: (i) The thematic structure including epistemic, algorithmic and/or heuristic structure, the larger context and normative reflection; (ii) The surface structure of an explanation which coincides with the comprehensibility criteria of Langer et al. (2011); (iii) The communication between explainer and learners on a personal level (referring to their relationship) as well as on a factual level (referring to the consideration of previous knowledge); (iv) The micro-methods used in an explanation, such as provocation, metaphors, or questions.

Notice that Schneider's model refers to complete lectures, while Aff's model remains on a quite abstract level, and Geissler, Kögler and Pachlinger's analysis focuses on the mental activities of explainers.

Based on this background, we developed comprehensive and specific guidelines that can be used in business teacher training for the preparation, realisation and reflection of instructional explanations in the subject areas of business administration, accounting, economics and business informatics (see Schopf & Zwischenbrugger, 2015a and 2015b). The HCEBE is described in the next section.

2.5 The Heuristic of Comprehensible Explaining in Business Education (HCEBE)

The HCEBE is based on a cognitivist approach to learning. It refers specifically to cognitive load theory, which builds on schema theory (see e.g. Sweller, 1994; Sweller, vanMerrienboer, & Paas, 1998). According to this view, learning is the acquisition and automation of schemas and can only occur as long as working memory is not overloaded. It is important to consider that explanations can support schema acquisition, but not schema automation as this requires practice, that existing schemas determine how new

DOI: https://doi.org/10.23770/suffix

information is processed and that explanations should be designed in a way that reduces extraneous and maximises germane cognitive load in order to promote learning.

Figure 1 illustrates the HCEBE on an abstract level. The starting point for an instructional explanation is the *previous knowledge* of the students, and the desired results are (predefined) *learning gains*. The HCEBE shows which elements an instructional explanation should contain and which attributes it should have in order to ensure comprehensibility. Notice that no rigid sequence for addressing the elements during an explanation is suggested.

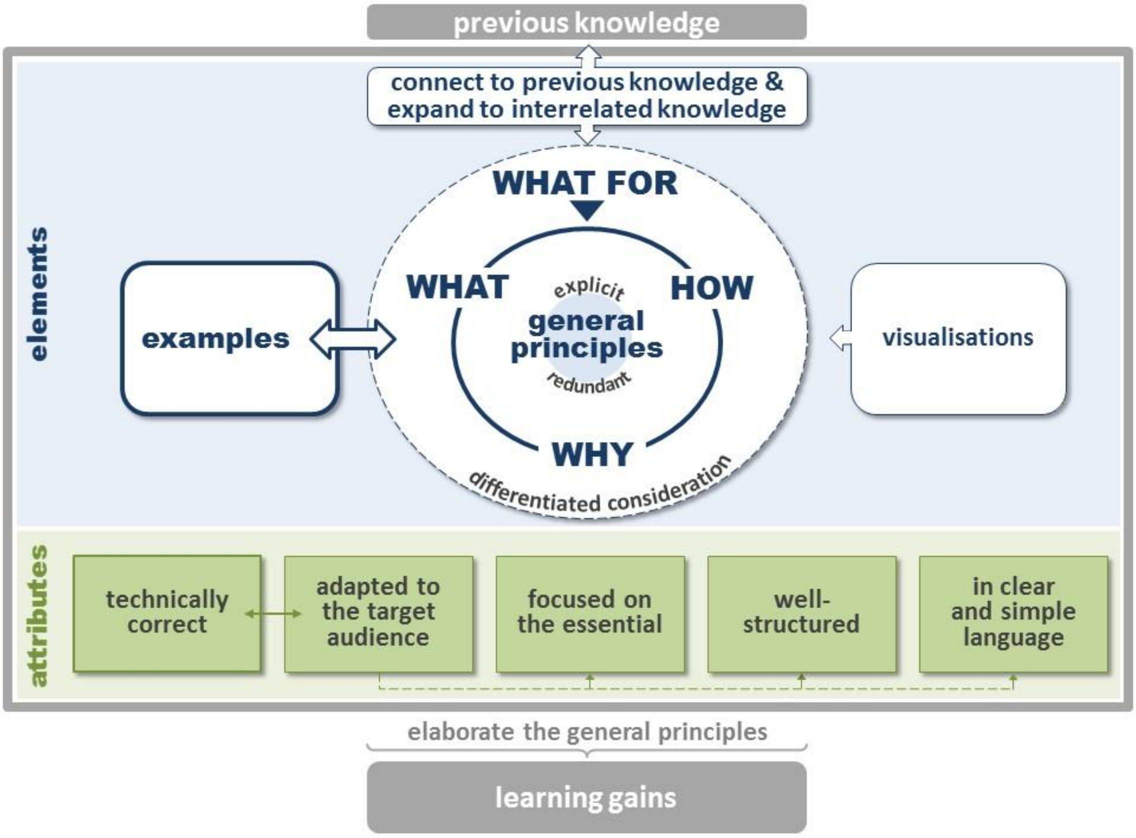

Fig. 1: The Heuristic of Comprehensible Explaining in Business Education (HCEBE) (Schopf & Zwischenbrugger, 2015a, p. 20, translated)

Elements of a comprehensible explanation

- It is important that an explanation *connects to* and (explicitly) builds on relevant *previous knowledge*, more precisely, on primarily subject-specific knowledge, but also experiences from everyday life or information from the news.
- An explanation should answer four fundamental questions with the objective to *elaborate general principles*: The question "*What is it?*" refers to the epistemic structure. In this context, relevant terms and concepts should be described and technical terms should be explained. The question "*How does it work?*" concerns the algorithmic or heuristic structure and aims to clarify procedures or strategies that are appropriate to tackle certain problems. The questions "*Why is it like that?*" and "*Why does it work like that?*" should also be addressed with the aim of substantiating

concepts, naming conventions, procedures and strategies. Moreover, the significance of the explained concept for the economy and/or society, its purpose and/or areas of application should be clarified by answering the question "*What is it needed for?*". The *general principles* which refer to abstract concepts and rules should be stated explicitly.

- It is equally important for students' understanding that the general principles are also shown implicitly by the use of *examples*, which at the same time ensures some beneficial *redundancy*. Examples might originate from the students' everyday life or from business practice, ideally touching on both worlds. The following recommendations for the design of good examples in business education can be given: An example needs to be appropriate to clearly illustrate the general principles, and should cover all aspects which are crucial for understanding. An example should treat a typical case especially if the content is completely new to the students, thus, exceptions and counterexamples should be avoided. An example should be made concrete by specifying, for instance, situations, actors, products, or quantities. It should also be ensured that the example is either based on reality or at least realistic and up-to-date. Whenever possible, original material, such as statistics, newspaper articles, legal texts, documents, photos or videos, should be considered. At the same time, an example should be related to the students' own reality, which means that the situations, enterprises, products etc. that are used should be familiar to the students or at least easily imaginable. It might therefore be necessary to didactically reduce the complexity of real-world examples.
- The whole verbal explanation should be supported by *visualisations*. Types of visualisations include (i) written information such as notes on the blackboard, (ii) graphic visualisations like graphic structures showing hierarchical or non-hierarchical relationships or processes, graphs, T-accounts, diagrams, pictures, videos or caricatures, (iii) visualisations with the help of subjects or objects, such as gestures, installations, role-plays or demonstrations of objects, and (iv) demonstrations of websites or computer programs. In a wider sense, metaphors and analogies can also be understood as (mental) visualisations. It is essential that the visualisations adequately illustrate the content and are well integrated into the verbal explanation in order to avoid split-attention.
- To help students see the big picture, an explanation should *expand to interrelated knowledge* from other topics covered in the same or other subjects.
- An explanation should also encourage *differentiated considerations* at a factual level (e.g., comparing different theoretical approaches, discussing limitations of models and underlying assumptions) as well as at a normative level (e.g., adopting social, ethical and ecological perspectives).

Attributes of a comprehensible explanation

- It is essential that an explanation is *technically correct*. In business education this includes the degree of practical relevance and novelty. Moreover, an explanation should be precise and avoid vague or ambiguous statements, and use technical terms correctly.

DOI: https://doi.org/10.23770/suffix

- An explanation should be *adapted to the target audience* in two dimensions: (i) Concepts which the learners may not be familiar with should be avoided. Also, the scope and level of complexity and the pace should be appropriate for the audience. (ii) Regarding the language, the register and linguistic abilities of the learners should be considered. Notice that there might be a trade-off between adapting an explanation to the target audience and technical correctness. Didactic reduction might be called for, but should never go so far as to make an explanation incorrect.
- *Focusing on the essential* is important during an explanation. This can be achieved by clearly defining the topic and by avoiding digression, reducing the content to the essence, identifying the keys, and highlighting the most important points verbally and/or visually.
- An explanation should be *well-structured*. In particular, new concepts should be developed step by step and the steps should follow a logical sequence according to the thematic structure and/or the learning process. The structure should also be made evident for the learners, such as, by raising the central questions and giving an advance organizer at the beginning as well as marking and visualising the single steps during the explanation.
- *Clear and simple language* should be used throughout the whole explanation, e.g., by using simple words and sentences, consistent diction, connection words, as well as by avoiding any vagueness and abbreviations.

3 Discussion of the scope of the HCEBE

As its name indicates, the HCEBE focuses on the comprehensibility of instructional explanations in business education at the secondary level, which implies that motivational aspects are not explicitly considered. However, it can be assumed that comprehensibility and motivation are closely linked (see e.g. Wilson & Mant, 2011), which makes us believe that we can, nevertheless, speak of guidelines for effective explaining.

As subjects unrelated to business education were not taken into account in the design of the HCEBE, the description of the elements and attributes is domain-specific. On the one hand, as explanations differ substantially in detail depending on the structure of the discipline according to Leinhardt (2001, p. 344), the question arises as to whether or not the scope of such guidelines should even be narrowed down to just one specific subject (area). In the light of this, Findeisen (2017) elaborated a set of 26 quality criteria for analysing teacher explanations in accounting, based on an extensive literature review. These were grouped into the five categories of subject content, learner centricity, process structure, representation and language. Also, Schopf (2018) focused on the subject of accounting in her interview study with business college students on characteristics of effective teacher explanations. Both publications give relevant subject-specific insights on a concrete level. On the other hand, on an abstract level the identified criteria as well as the HCEBE seem to be quite generic and therefore applicable to diverse subject areas and target audiences. Despite the different perspectives and structures, most of Findeisen's criteria can be related to the elements and attributes of the HCEBE and they overlap significantly with those derived from Schopf's student interviews. Moreover, the elements and attributes of the HCEBE widely coincide with quality criteria mentioned in general didactics as shown in Figure 2.

	Brophy & Good, 1986	Brown, 2006	deWin-stanley & Bjork, 2002	Gudjons, 2007	Helmke, 2007	Mac Donald, 1991	Wellen-reuther, 2015	Wittwer & Renkl, 2008	Zwozdiak-Myers & Capel, 2009
elements (HCEBE)									
connect to previous knowledge	X		X			X	X	X	X
expand to interrelated knowledge	X		X						
what		X				X			X
how		X				X			X
why		X				X			X
what for			X	X		X	X		
general principles	X		X	X					X
examples		X	X	X			X		X
visualisations		X	X	X		X	X		X
attributes (HCEBE)									
technically correct					X				
adapted to the target audience	X	X				X		X	X
focused on the essential	X	X			X	X	X	X	
well-structured	X	X	X	X	X				X
in clear and simple language		X		X	X				

Fig. 2: Quality criteria for explanations found in general didactic literature related to the HCEBE

	Charalam-bous et al., 2011	Drollinger-Vetter, 2011	Fahse & Linnemann, 2015	Forman & Rash, 2015	Kiel et al., 2015	Leinhardt, 1987	Roberts, 1999	Röhrl & Krauss, 2017	Wagner & Wörn, 2011
elements (HCEBE)									
connect to previous knowledge		X				X	X		X
expand to interrelated knowledge		X							X
what	X	(X)							(X)
how	(X)	(X)							(X)
why		(X)			X				(X)
what for	X	X			X	X		X	(X)
general principles	X	(X)	X		X	X	X		
examples	X	(X)	X	X		X	X	X	X
visualisations	X	(X)	X	X	(X)	(X)	(X)	X	X
attributes (HCEBE)									
technically correct				X	X				X
adapted to the target audience	X				X		X		X
focused on the essential			X	X	X		X		X
well-structured	X	X		X					X
in clear and simple language	X				X			X	

Figure 3: Quality criteria for explanations found in mathematics didactic literature related to the HCEBE (An X marks the explicit appearance of an element or attribute in the named publication, while an (X) marks the implicit appearance.)

DOI: https://doi.org/10.23770/suffix

Figure 3 shows that most of the criteria proposed in mathematics didactic literature can also be related to the elements and attributes of the HCEBE, although two main conceptual differences have been identified: (i) While a complete instructional explanation includes what, how and why according to the HCEBE, these three questions are answered by different types of explanations in mathematics didactic literature. Here, the components of an explanation are conceptualised – at a different analytical level – as content-specific elements necessary for understanding. (ii) While the HCEBE considers the general principles, examples and visualisations as core elements of an instructional explanation, in mathematics didactic literature the focus is on different forms of content representation, that is, verbalisation and enactive, iconic or symbolic visualisation. In this context, examples in the form of tasks play an important role, mostly as a starting point for an explanation (Wörn, 2014, p. 190). In addition, analogies and metaphors are of particular significance in mathematical explanations, especially when the audience has sparse previous knowledge (Forisek & Steinova, 2013, p. 3ff; Kiel et al., 2015, p.3).

4 Transference of the HCEBE to teaching operations research

4.1 Interview study

The objective of our interview study was to investigate quality criteria for explanations in teaching operations research at university level, from the perspective of professors from the international operations research community. Eight interviewees (six male, two female) were selected according to their scientific track record (h-index 34 on average) and their research and teaching experience (88 published articles, 34 years of experience on average). It is worth noting that none of them had a profound education in didactics. They were also chosen such that they are all currently affiliated with universities in different countries, specifically in Austria, Brazil, Chile, France, Scotland, Spain, Switzerland, United States. We remark that the number of eight interviewees is appropriate to derive useful results according to Marshall et al. (2013). The new contributions of the last two interviewees have also been significantly lower than 20% which guarantees a certain level of saturation (Sargeant, 2012).

The semi-structured problem-centred interviews (Witzel, 1982, p. 66ff) were performed either face-to-face or via online conference with an average duration of 37 minutes and consisted of two parts: The main part was dedicated to the description of the interviewees' understanding of an effective explanation in teaching operations research. In the second part, the interviewees were familiarised with the HCEBE and asked to assess its applicability to teaching operations research.

4.2 Qualitative content analysis

All interviews were fully transcribed and subject to a qualitative content analysis (Mayring, 2014). The categories for the analysis were predefined, corresponding to the elements and attributes of the HCEBE, augmented with categories "miscellaneous elements" and "miscellaneous attributes" for collecting additional criteria mentioned by the interviewees, and a category "applicability" to collect the interviewees' comments on the HCEBE in the second part of the interview. The whole material was coded according to the following rules: (i) statements that unambiguously belonged to a category were coded therein; (ii) statements that unambiguously belonged to a specific category based on the context they were mentioned (although they could have been coded to more categories when neglecting the context) were coded therein; (iii) ambiguous statements were coded to all related categories, however, these cases were very rare. The coding was performed by one of the authors and tested by re-coding two interviews resulting in intra-coder reliability measured by Cohen's $\varkappa \approx 0.64$. All statements were then paraphrased, reduced and generalized. Finally, the identified main statements of all interviews were collated in each category.

4.3 Results

Figure 4 illustrates the reduced and generalized statements of the interviewees made before the HCEBE was presented to them together with the number of mentions. That is, a concise description of their own understanding of effective instructional explanations in teaching operations research. Note that the column "intersection" shows aspects mentioned independently by at least half of the interviewees, while the column "additional comments" adds further relevant aspects stated by less than half of the interviewees. The statements belonging to categories "miscellaneous" as well as the comments regarding the applicability of the HCEBE to teaching operations research are also presented.

Category	Intersection	Additional comments
	elements (HCEBE)	
connect to previous knowledge	▪ Explanations should connect to the previous knowledge of the target audience, since this is the key for further understanding (8/8).	▪ One should also connect to interrelated knowledge if possible (3/8). ▪ There must exist a certain level of knowledge, i.e., one cannot adapt to all students (2/8).
examples	▪ Examples are crucial since they support understanding and intuition (8/8). ▪ It is preferable to start with a simple example (6/8). ▪ Examples should cover the (main) points of an explanation (5/8). ▪ Examples should be realistic and ideally fancy (5/8).	▪ Examples should be of practical relevance, up-to-date, and touch the everyday reality of the students (4/8). ▪ Counter-examples are helpful to show when a concept breaks down (4/8). ▪ There is a trade-off between giving realistic examples and simplicity which should be considered (3/8).

DOI: https://doi.org/10.23770/suffix

	▪ Books are good sources for examples which can be adapted if necessary (5/8).	▪ An approach to deal with the aforementioned tension, is to ask why simple assumptions are unrealistic in a specific case (2/8). ▪ Case-studies are good examples, since they cover most of the aforementioned points, and make the students think about the problems (1/8).
visualisations	▪ Visualisations are important and support understanding as well as intuition (8/8). ▪ Visualisations should be simple and concisely depict the concept being explained (6/8). ▪ Especially in mathematics visualisations need to be explained since they are often not self-explanatory (5/8).	▪ Visualisations support viewing a problem from different angles (3/8). ▪ Visualisations are a good tool since they can be easily memorized (3/8). ▪ Visualisations should evolve dynamically on the blackboard or on slides (3/8). ▪ Visualisations should depict a generic case (2/8).
general principles	▪ General principles should be stated but providing intuition is more important than principles in most cases (7/8).	▪ Especially when teaching non-mathematicians in operations research, general principles should neither be too general, nor too specific (4/8). ▪ Ideally, general principles and intuition are given and linked together (3/8). ▪ A certain level of redundancy often supports overall understanding (2/8).
differentiated consideration	▪ Viewing a problem from different angles is important, and one should also demonstrate when a concept fails (6/8).	▪ It is always advisable to discuss advantages and disadvantages of a concept (4/8). ▪ Disadvantages should be stated carefully to avoid confusion (3/8).

what, how, why, what for	▪ It is important to provide intuition, which supports understanding why something works (5/8).	▪ Demonstrating how something works is crucial and can be supported by simple examples, but it is more important to explain why something works (3/8). ▪ It is crucial to clarify why considering the discussed problem is important (2/8). ▪ It is important to state what the problem is (1/8).
▪ attributes (HCEBE)		
HCEBE attributes	▪ Explanations should be well-structured and presented in a logical order (7/8). ▪ Explanations should be geared to the target audience (7/8) ▪ Explanations should focus on the essence (5/8).	▪ Explanations should be somehow thrilling and sexy and keep the attraction of the audience (e.g., by body language) (2/8). ▪ The language should be appropriate for the audience (2/8). ▪ All statements should be (technically) correct to avoid confusion (1/8). ▪ One should speak with a loud voice such that everyone can clearly hear the explanation (1/8).
▪ miscellaneous (elements)		
miscellaneous elements	▪ Mathematical proofs are important for students of mathematics, but not for all students (6/8). ▪ It is advisable to present proofs at a basic level, i.e., presenting the main ideas, and skipping technical details (5/8). ▪ The presentation of proofs should be well-prepared and ideally performed on the blackboard, which gives	▪ An outline (or strategy) of a proof should be given (4/8). ▪ Pauses during an explanation should be included which give students enough time to think (3/8). ▪ If possible, some historical background to the topic should also be explained (2/8).

	enough time for thinking (5/8). ▪ Explanations should contain some surprising elements (5/8).	
▪ miscellaneous (attributes)		
miscellaneous attributes	▪ Explanations should be motivating (5/8). ▪ Explanations should be of the right length and respect the capacity of the students' attention (5/8). ▪ Using the blackboard ensures the right pace of an explanation (5/8).	▪ Explanations should evolve dynamically (3/8). ▪ Explanations should be presented in a way that allows the students to believe they are clever, which gives them confidence, motivates them and typically extends the duration of their attention (2/8).
▪ applicability		
applicability	▪ The HCEBE is a useful and generic framework for beginners of teaching (8/8).	▪ The key elements and attributes are contained in the HCEBE, hence, adding more elements and attributes one can easily loose generality (4/8).

Fig. 4: Summarized generalized statements of the interview study (The number of mentions is reported in brackets after each statement, e.g., (5/8) means that five of eight interviewees mentioned that aspect.)

4.4 Discussion of the applicability of the HCEBE

It is obvious that the results from this interview study cannot be generalised. Anyhow, they do show that there are many overlaps between those elements and attributes of an instructional explanation considered as important by the interviewees and those proposed in the HCEBE. We observe from Figure 4 that all interviewees agreed that connecting to previous knowledge of the target audience and including examples in explanations is crucial. The importance of visualisations was also recognised by all interviewees, but comments did not go into detail on this point. It is worth noting that talking about aspects of good visualisations was perceived as a difficult task. Although stating principles was considered relevant, providing intuition was regarded as more important than stating principles. Moreover, most interviewees agreed that a problem should be viewed from different perspectives during an explanation. It might be surprising that the central questions were not addressed (explicitly) in most interviews. The later discussion of the HCEBE showed, however, that answering those questions was perceived as important, but considered as trivial by most interviewees. Regarding the attributes of the HCEBE we observe that most interviewees commented that explanations should be well-structured, geared to the target audience, and focus on the essence. In contrast, explaining technically correct and in clear and simple language was not mentioned often since it was perceived as trivial. The additional element "mathematical proof" might be seen as a sub-category of the why-question, although a proof is a somewhat stronger statement since it can often be explained why a concept works without proving it. "Surprising elements" will often be connected to examples. The attributes "right length" and "right pace" are not explicitly mentioned in the HCEBE, but might be subsumed under the attributes "focused on the essential" or "adapted to the target audience", respectively. Finally, presenting explanations in a way that generates enthusiasm for the subject is obviously crucial.

The interviewees' comments on the HCEBE after its presentation in the second part of the interview were overall positive. The consensus was that it is a useful, generic and appropriate framework for designing explanations, especially for beginner teachers.

5 Conclusions and implications

Our investigations substantiate that, although the HCEBE was originally designed for business teaching at business colleges, it can be transferred well to other subjects and contexts on an abstract level, since the proposed elements and attributes seem to be generally important for giving effective explanations. Whenever the objective is to teach general principles which can be used to deal with certain types of tasks or problems, these principles should be presented in an explicit way and examples as well as visualisations should be used to support learning. Connecting to previous knowledge is crucial for understanding in any case and the expansion to interrelated knowledge helps in forming the big picture. The technical correctness of an explanation and its adaptation to the target audience are indispensable preconditions. Keeping the focus on the essential, following a clear structure, and using clear and simple language facilitate understanding. A comparison of the HCEBE with quality criteria for explanations in teaching accounting, which is one specific subject within the domain of business education, as well as with criteria from general didactic literature and especially an analysis of mathematics didactic literature on explanations show substantial overlaps. Furthermore, our interviews with professors from the international scientific community in operations research document the applicability of the HCEBE for teaching that subject at university level.

Nevertheless, it is important to remember that the specific design and realisation of the elements and attributes of the HCEBE need to be adapted to the subject-matter and the specific content, as well as the context. That is to say, what the essential is, what kinds of examples and visualisations are appropriate or what technical terms can/should be used etc., strongly depends on the specific content to be explained and the target audience. Moreover, how the elements and attributes of the HCEBE are weighted may vary depending on each individual case. Possible questions that teachers should ask themselves are, for instance: "Which of the four central questions should be emphasised?", "Is the focus on formulating general rules or on presenting various examples?", "To what extent should a concept be didactically reduced?". Similarly, the sequence of the elements may vary, that is, in what order the central questions are addressed, whether the explanation evolves inductively or deductively, or which aspects are visualised.

In conclusion, the HCEBE provides a fairly solid generic framework for the analysis and the design of instructional explanations on an abstract level. Thus, it seems to be beneficial to include it in teacher education as a general tool and as a starting point for further subject-didactic elaborations.

Acknowledgements

We would like to thank all interviewees for their valuable contributions to our study. This support is gratefully acknowledged!

References

Aff, J. (2016). Impulse allgemeindidaktischer Modelle für einen professionellen ökonomischen Unterricht. Exemplarische Veranschaulichung der Potenziale der kritisch-konstruktiven Didaktik (Klafki) für eine ökonomische Fachdidaktik anhand der Themenstellung „Finanzmarktkrise". In A. Wegner (Ed.), *Allgemeine Didaktik: Praxis, Positionen, Perspektiven* (pp. 155–179). Opladen/Berlin/Toronto: Budrich.

Ballstaedt, S.-P. (1997). *Wissensvermittlung. Die Gestaltung von Lernmaterial*. Weinheim: Psychologie Verlags Union.

Biere, B. U. (1989). *Verständlich-Machen. Hermeneutische Tradition – Historische Praxis – Sprachtheoretische Begründung*. Tübingen: Max Niemeyer.

Bligh, D. A. (1974). *What's the Use of Lectures?* Harmondsworth et al.: Penguin.

Brophy, J., & Good, T. L. (1986). Teacher Behavior and Student Achievement. In M. C. Wittrock (Ed.), *Handbook of Research on Teaching* (pp. 328–375). New York: Macmillian.

Brown, G. (2006). Explaining. In O. Hargie (Ed.), *The handbook of communication skills* (pp. 195–228). East Sussex: Taylor and Francis.

Charalambous, C. Y., Hill, H. C., & Ball, D. L. (2011). Prospective teachers' learning to provide instructional explanations: how does it look and what might it take? *Journal of Mathematics Teacher Education*, *14*(6), 441–463.

Christmann, U., & Groeben, N. (1999). Psychologie des Lesens. In B. Franzmann, K. Hasemann, D. Löffler, & E. Schön (Eds.), *Handbuch Lesen* (pp. 145–223). München: K. G. Saur.

deWinstanley, P. A., & Bjork, R. A. (2002). Successful Lecturing: Presenting Information in Ways That Engage Effective Processing. *New Directions for Teaching and Learning, 89(-)*, 19–31.

Drollinger-Vetter, B. (2011). *Verstehenselemente und strukturelle Klarheit. Fachdidaktische Qualität der Anleitung von mathematischen Verstehensprozessen im Unterricht*. Münster et al.: Waxmann.

Dubs, R. (2009). *Lehrerverhalten: Ein Beitrag zur Interaktion von Lehrenden und Lernenden im Unterricht*. Stuttgart: Franz Steiner.

Duffy, G. G., Roehler, L. R., Meloth, M. S., & Vavrus, L. G. (1986). Conceptualizing instructional explanation. *Teaching & Teacher Education*, *2*(3), 197–214.

Ehlich, K. (2009). Erklären verstehen – Erklären und Verstehen. In R. Vogt (Ed.), *Erklären. Gesprächsanalytische und fachdidaktische Perspektiven* (pp. 11–24). Tübingen: Stauffenburg.

Erath, K., & Prediger, S. (2015). Lernende beim Navigieren auf „Erklärpfaden" mitnehmen. *PM: Praxis der Mathematik in der Schule*, *57*(64), 33–37.

Euler, D., & Hahn, A. (2007). *Wirtschaftsdidaktik*. Bern/Stuttgart/Wien: Haupt.

Fahse, C., & Linnemann, T. (2015). Genügt der Beweis, oder soll ich das auch erklären?: Gute Begründungen und Erklärungen aus Sicht der Schülerinnen und Schüler. *PM: Praxis der Mathematik in der Schule*, *57*(64), 19–23.

Findeisen, S. (2017). *Fachdidaktische Kompetenzen angehender Lehrpersonen. Eine Untersuchung zum Erklären im Rechnungswesen*. Wiesbaden: Springer.

Forisek, M., & Steinova, M. (2013). *Explaining Algorithms Using Metaphors*. London et al.: Springer.

Forman, S., & Rash, A. M. (2015). *The Whole Truth About Whole Numbers: An Elementary Introduction to Number Theory*. Cham: Springer.

Gage, N. L., & Berliner, D. C. (1984). *Pädagogische Psychologie, Band 2: Lehrmethoden, Bewertung des Lernerfolges*. Weinheim/Basel: Psychologie Verlags Union/Beltz.

Geelan, D. R. (2012). Teacher Explanations. In B. J. Fraser, K. G. Tobin, & C. J. McRobbie (Eds.), *Second International Handbook of Science Education* (pp. 987–999). Dordrecht et al.: Springer.

Geissler, G., Kögler, G., & Pachlinger, I. (2013). Erklärungen im Wirtschaftsunterricht. In J. Aff & R. Fortmüller (Eds.), *Entrepreneurship-Erziehung im wissenschaftlichen Diskurs. Beiträge zu gesellschaftlichen, lernpsychologischen und fachdidaktischen Aspekten einer modernen Entrepreneurship-Erziehung in Russland und Tadschikistan* (pp. 173–185). Wien: Manz.

Gudjons, H. (2007). *Frontalunterricht – neu entdeckt. Integration in offene Unterrichtsformen*. Bad Heilbrunn: Klinkhardt.

Hattie, J. (2009). *Visible learning: a synthesis of meta-analyses relating to achievement.* London/New York: Routledge.

Helmke, A. (2007). Lernprozesse anregen und steuern. Was wissen wir über Klarheit und Strukturiertheit? *Pädagogik*, *59*(6), 44–47.

Hines, C. V., Cruickshank, D. R., & Kennedy, J. J. (1985). Teacher Clarity and Its Relationship to Student Achievement and Satisfaction. *American Educational Research Journal*, *22*(1), 87–99.

Inoue, N. (2009). Rehearsing to teach: content-specific deconstruction of instructional explanations in pre-service teacher training. *Journal of Education for Teaching, 35*(1), 47–60.

Kaiser, F.-J., & Kaminski, H. (2012). *Methodik des Ökonomieunterrichts: Grundlagen eines handlungsorientierten Lernkonzepts mit Beispielen*. Bad Heilbrunn: Klinkhardt.

Kiel, E. (1999). *Erklären als didaktisches Handeln*. Würzburg: Ergon.

Kiel, E., Meyer, M., & Müller-Hill, E. (2015). Erklären: Was? Wie? WARUM? *PM: Praxis der Mathematik in der Schule*, *57*(64), 2–9.

König, J., Lammerding, S., Nold, G., Rohde, A., Strauß, S., & Tachtsoglou, S. (2016). Teachers‘ Professional Knowledge for Teaching English as a Foreign Language: Assessing the Outcomes of Teacher Education. *Journal of Teacher Education, 67*(4), 320–337.

Langer, I., Schulz von Thun, F., & Tausch, R. (2011). *Sich verständlich ausdrücken*. Münster: Ernst Reinhardt.

Leinhardt, G. (2001). Instructional Explanations: A Commonplace for Teaching and Location for Contrast. In V. Richardson (Ed.), *Handbook Of Research On Teaching* (pp. 333–357). Washington D.C.: American Educational Research Association.

Leinhardt, G. (1987). Development of an Expert Explanation: An Analysis of a Sequence of Subtraction Lessons. *Cognition and Instruction*, *4*(4), 225–282.

MacDonald, R. E. (1991). *A handbook of basic skills and strategies for beginning teachers: facing the challenge of teaching in today's schools*. New York/London: Longman.

Marshall, B., Cardon, P., Podder, A., & Fontenot, R. (2013). Does sample size matter in qualitative research? A review of qualitative interviews in IS research. *Journal of Computer Information Systems, 54(1),* 11–22.

Mayring, P. (2014). *Qualitative content analysis: theoretical foundation, basic procedures and software solution*. Klagenfurt. Retrieved from https://nbn-resolving.org/urn:nbn:de:0168-ssoar-395173.

Odora, R. J. (2014). Using Explanation as a Teaching Method: How Prepared Are High School Technology Teachers in Free State Province, South Africa? *Journal of Social Sciences, 38*(1), 71–81.

Perry, M. (2000). Explanations of Mathematical Concepts in Japanese, Chinese, and U.S. First-and Fifth-Grade Classrooms. *Cognition and Instruction, 18*(2), 181–207.

Roberts, R. (1999). *What Makes An Explanation A Good Explanation? Adult Learners' Criteria For Acceptance Of A Good Explanation* (Master thesis). Memorial University of Newfoundland.

Roehler, L. R., & Duffy, G. G. (1986). What Makes one Teacher a Better Explainer than Another. *Journal of Education for Teaching*, *12*(3), 273–284.

Röhrl, S., & Krauss, S. (2017). Erfolgreiches Erklären im Mathematikunterricht. In U. Kortenkamp & A. Kuzle (Eds.), *Beiträge zum Mathematikunterricht 2017* (pp. 1149–1152). Münster: WTM.

Sergeant, J. (2012). Qualitative research part II: Participants, analysis, and quality assurance. *Journal of Graduate Medical Education 4(1),* 1–3.

Schilcher, A., Krauss, S., Rincke, K., & Hilbert, S. (2017). Ausblick – Aus FALKO wird FALKE: Fachspezifische Lehrerkompetenz im Erklären. In S. Krauss, A. Lindl, A. Schilcher, M. Fricke, A. Göhring, B. Hofmann, P. Kirchhoff, & R. H. Mulder (Eds.), *FALKO: Fachspezifische Lehrerkompetenzen: Konzeption von Professionswissenstests in den Fächern Deutsch, Englisch, Latein, Physik, Musik, Evangelische Religion und Pädagogik* (pp. 439–451). Münster/New York: Waxmann.

Schmidt-Thieme, B. (2009). „Definition, Satz, Beweis" – Erklärgewohnheiten im Fach Mathematik. In R. Vogt (Ed.), *Erklären. Gesprächsanalytische und fachdidaktische Perspektiven* (pp. 123–131). Tübingen: Stauffenburg.

Schneider, W. (1995). *Informieren und Motivieren. Eine Einführung in die Präsentationstechnik*. Wien: Manz.

Schopf, C. (2018). Verständliche und motivierende Erklärungen im Rechnungswesenunterricht. Rekonstruktion der Schülervorstellungen auf Basis einer Interviewstudie. *Zeitschrift für Berufs- und Wirtschaftspädagogik, 114*(4), 609–637.

Schopf, C., & Zwischenbrugger, A. (2015a). *Handbuch verständlich erklären. Eine Heuristik mit Beispielen aus Betriebswirtschaft, Rechnungswesen, Volkswirtschaft und Wirtschaftsinformatik*. Wien: Manz.

Schopf, C., & Zwischenbrugger, A. (2015b). Verständliche Erklärungen im Wirtschaftsunterricht. Eine Heuristik basierend auf dem Verständnis der Fachdidaktiker/innen des Wiener Lehrstuhls für Wirtschaftspädagogik. *Zeitschrift für ökonomische Bildung, 3*, 1–31.

Shulman, L. S. (1986). Those who understand. Knowledge Growth in Teaching. *Educational Researcher, 15*(2), 4–14.

Sweller, J. (1994). Cognitive load theory, learning difficulty, and instructional design. *Learning and Instruction, 4*(4), 295–312.

Sweller, J., vanMerrienboer, J., & Paas, F. (1998). Cognitive Architecture and Instructional Design. *Educational Psychology Review, 10*(3), 251–296.

Treagust, D. F., & Harrison, A. G. (2000). In search of explanatory frameworks: an analysis of Richard Feynman's lecture 'Atoms in motion'. *International Journal of Science Education, 22*(11), 1157–1170.

Wagner, A., & Wörn, C. (2011). *Erklären lernen – Mathematik verstehen: Ein Praxisbuch mit Lernangeboten*. Seelze: Kallmeyer/Klett.

DOI: https://doi.org/10.23770/suffix

Wellenreuther, M. (2015). *Lehren und Lernen – aber wie?: Empirisch-experimentelle Forschungen zum Lehren und Lernen im Unterricht*. *Grundlagen der Schulpädagogik: Vol. 50*. Baltmannsweiler: Schneider.

Wilbers, K. (2014). *Wirtschaftsunterricht gestalten: Toolbox*. Berlin: epubli.

Wilson, H., & Mant, J. (2011). What makes an exemplary teacher of science? The pupils' perspective. *School Science Review*, *93*(342), 121–125.

Wittwer, J., & Renkl, A. (2008). Why Instructional Explanations Often Do Not Work: A Framework for Understanding the Effectiveness of Instructional Explanations. *Educational Psychologist*, *43*(1), 49–64.

Witzel, A. (1982). *Verfahren der qualitativen Sozialforschung: Überblick und Alternativen*. Frankfurt/New York: Campus.

Wörn, C. (2014). *Unterrichtliche Erklärsituationen: Eine empirische Studie zum Lehrerhandeln und zur Kommunikation im Mathematikunterricht der Sekundarstufe I*. *Schriftenreihe Didaktik in Forschung und Praxis: Vol. 74*. Hamburg: Dr. Kovac.

Zwozdiak-Myers, P., & Capel, S. (2009). Communication with Pupils. In S. Capel, M. Leask, & T. Turner (Eds.), *Learning to Teach in the Secondary School: A Companion to School Experience* (pp. 107–123). London: Routledge.

Christiane Schopf

is Assistant Professor at the Institute for Business Education at WU – Vienna University of Economics and Business, Austria

Andrea Raso

is Post Doc at the Institute for Business Education at WU – Vienna University of Economics and Business, Austria

Michael Kahr

is a researcher and PhD candidate at the Department of Statistics and Operations Research, University of Vienna, Austria

DOI: https://doi.org/10.23770/suffix