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Research Paper

A review of applications of the repertory grid technology in research on education and educational psychology

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ABSTRACT

The present study utilized a methodological review to construct a model, explaining the possible applications of the repertory grid technique (RGT) in research on education and educational psychology. Basically, the RGT is a method usually used to elicit and explore subjects' personal constructs. It allows integrations of both qualitative and quantitative methods for data collection and analysis. Recently, the development of RGT computer programs extends its applications. First, the analytic strategies of RGT helps to explore internal structures of grid data using systemic strategies which enables researchers to examine subjects' cognitive structures, usually seen as a complex task, in a more structured way. Second, these analytic strategies could also be used for other purposes, such as exploring the learning problems (or misconceptions) of novice learners, revealing the structure of text data, and constructing principles based on data collected from persons regarded as experts. Moreover, the RGT allows for comparison analysis which provides subjects with opportunities to review and reflect on the changes in their knowledge structures before and after instruction. This comparison analysis also enables researchers to investigate similarities or differences among the collected constructs across individuals. We expect that our discussion of RGT applications can provide new information for researchers to deepen and extend their investigations in the given field.

Key words: Kelly's repertory grid technology, research methodology, literature review, education, educational psychology.

INTRODUCTION

In education and educational psychology research, the repertory grid technique (RGT) has been shown to be a fertile instrument for eliciting subjects' personal knowledge, making generalizations, and identifying hidden dimensions within subjects' knowledge(Ben- Zvi Assaraf and Orion, 2010; Ben-Zvi Assaraf et al., 2012; Edwards et al., 2009; Jankowicz, 2004). The RGT was created by George Kelly (1955), a psychologist and educator best known for his theory of personal construct psychology (PCP). Kelly believed that every individual constructs their personal experience and knowledge through a series of processes including the generation and testing of hypotheses, followed by decisions as to what should be reserved, revised, or abandoned (Bradshaw, Ford et al., 1993; Edwards et al., 2009). The RGT was mainly used in clinical settings at first, as a means of facilitating psychologists' interpretations of how clients view and shape their worlds, but applications of the RGT have been extended to other areas over time. The development of relevant computer programs in recent years (e g., Idiogrid, Gridcor, Gridsuite, Planet, Webgrid, and so on) has enabled the RGT to be used in dealing with complex and multiple types of data. A number of statistic analytical approaches, such as descriptive statistics analysis, principal component analysis, and cluster analysis, have thereby been integrated into the analysis of the RGT, providing

researchers with a systematic way to explore subjects' cognitive structures. Even so, we consider the RGT as simply not a mainstream research method in education and educational psychology research, because a July 2016 search of various educational databases (e.g., JSTOR, ERIC, EBSCO) for articles using "repertory grid" in the title or as keyword revealed a total of only 55 relevant studies over the last 30 years. Among those 55 studies, 39 empirical studies were selected as the main materials for our literature review in the present study. The first concern of our review was to determine the research purposes of the various studies. Relatedly, we intend to clarify what kinds of research purposes applications of the RGT are appropriate for. However, we found the research purposes of the studies in question to be quite diverse, which required further clarification of the research topics, the methods used for data collection and analysis, and the features of the study participants (e.g., grade levels and prior knowledge) in order to improve our understanding. Specifically, the main purpose of our literature review was to assist readers/researchers in the creation of future research purposes to allow for deeper investigations in their given fields based on the RGT methodology. As a result, we constructed a model to illustrate the conclusions of our literature review (Figure 1). The center of the model shows the main concern of the present study, namely, the features of research purposes appropriate for the RGT. The three squares in the first outer layer of the model indicate three basic features of RGT-related research purposes. The squares in the second outer layer show subclasses of the three basic features.

The sections which follow were organized according to our model. Table 1 presents a summary of the information for each of the empirical studies reviewed in our literature exploration.

Elicitation and interpretation of personal knowledge

Understanding subjects in terms of their pre-existing knowledge

The standard methods used in applying the RGT basically include five phases: a) selecting elements; b) eliciting constructs; c) establishing a repertory grid (RG); d) rating the RG; and e) analyzing the rating data in the RG. Based on Kelly's theory, elements could be cases, objects, things, ideas, topics, or concepts. The purpose of these elements is to elicit subjects' knowledge, understanding, attitude, personalities, and thinking on the topics of research. The basic strategies of elicitation include requesting subjects to make classifications, identifications, reasonings, and explanations (Kreber and Klampfleitner, 2012; Greatorex, 2001). For example, Kelly (1955) investigated subjects' personalities by having them classify a set of concepts as follow: self, mother, father, your closest friend of the same elements, and they are used as stimuli to elicit subjects' constructs. According to Kelly, a construct is an invention of a person, and hence it is personal and private. Different from elements, constructs reveal a subject's pre-existing knowledge. The method developed by Kelly best-known for eliciting personal constructs is called the triadic elicitation method (Epting et al., 1971). Generally, there are three phrases included in the triadic elicitation method: (a) the selection and grouping of elements in three as a triad; (b) asking the subject to explain how two elements of a triad are similar to each other and, therefore, different from the third one; (c) repeating the elicitation process using different triads. Through the triadic elicitation method, researchers are able to explore subjects' personal constructs with little intervention on the part of the researchers (Van Kan et al., 2010). A number of past studies applied the triadic elicitation method to elicit subjects' personal knowledge and understand the ways in which they perceive the given elements. Guo et al. (2011) employed the triadic elicitation method to explore university students' thinking and attitudes regarding computer-mediated communication (CMC) mediums. The elements selected and used in the study were communication mediums, such as email, instant messaging, wikis, blogs, social networking sites, and so on. After students' comments and thinkings were collected, content analysis was applied for further exploration. The authors reported that the RGT provided them with an effective way to identify a number of student-specific reasons regarding the use of CMC mediums in learning contexts. Ben-Zvi Assaraf et al. (2012) investigated tenth-grade students' knowledge of human body systems. During the data collection phase, the researchers asked the subjects to brainstorm twelve biology concepts related to human body systems (e.g., breathing, blood cells, and oxygen). These concepts were then treated as elements in the application of the triadic elicitation method. The elements were then supplied to the students to elicit their constructs. Through subsequent content analysis of the collected constructs, the researchers were able to understand how the students constructed their knowledge of human body systems. This understanding helped the researchers, in turn, to develop scaffolds to support students' learning. In our literature review, it was observed that using content analysis is a common strategy to explore the elicited constructs after the triadic elicitation method. This feature implied a basic application of the RGT.

Exploring the characteristics of constructs

In addition to making interpretations, another common purpose of the analysis of subjects' constructs is to explore their characteristics. Basically, the investigators have the authority to decide what elements should be selected for elicitation. However, it is suggested that investigators

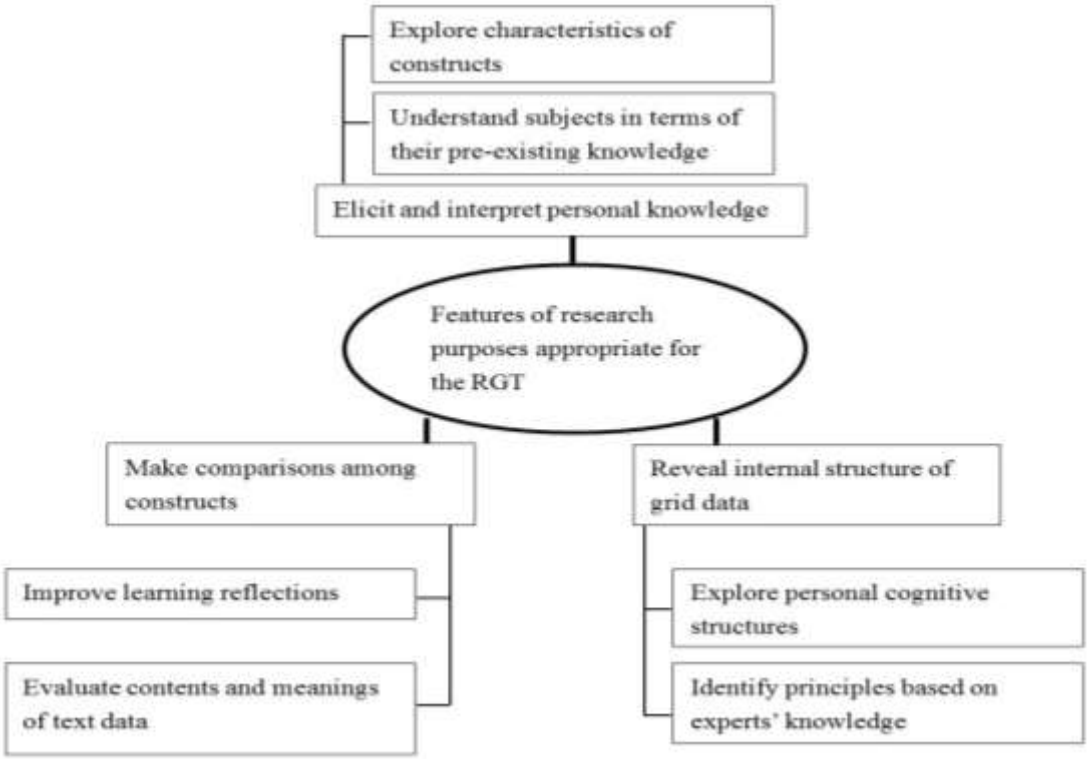

Figure 1. The applications of the RGT in education and educational psychology research.

should pick elements based on the subject's prior-knowledge (Cohen et al., 2007; Keynan et al., 2014). This consideration enables the investigators to elicit subjects' knowledge without misunderstanding and also supports the exploration of the characteristics of subjects' knowledge structures. Kreber and Klampfleitner (2012) applied the RGT to investigate teachers' conceptions of authenticity in teaching; nine lecturers from different academic fields were invited to participate. Ten characteristics for describing a university teacher were identified through discussions with the subjects', such as a typical university teacher, an effective teacher, and an authentic teacher. These characteristics were then treated as elements for eliciting the lecturers' constructs regarding authentic teachers, authenticity in teaching, and teaching effectiveness. As a result, the study identified six characteristics of the subjects' knowledge with regard to authenticity in teaching which provided evidence for further developments in both teacher education and philosophical theories on authenticity. In the study conducted by Ben-Zvi Assaraf et al. (2012), as mentioned above, all elements and constructs were identified and obtained through communications with the subjects. This communication process ensured that all selected elements were meaningful to all students and also supported the subsequent exploration of students' cognitive structures about their science learning.

Reveal internal structure of grid data

Explore personal cognitive structures

Although the RGT is a technique for eliciting people's knowledge, it allows, at the same time, for the integration of statistical analyses. In this regard, investigators may establish a RG, the third phase of the standard methods for applying the RGT we mentioned in last section, in order to collect quantitative data from subjects. There are various methods for establishing a RG, as well as different ways of rating a RG. The most common method is to place elements along the bottom side of a grid, and then put constructs on the two sides of the grid. Such a RG structure enables subjects to rate every pairing of an element and construct by adopting a 5- or 7-point rating scale mechanism. A high score (that is, 5 points or 7 points) is then given if the element and construct in a paring are considered to be closely related.

As soon as the quantitative data are collected, they can be analyzed by a series of approaches, such as descriptive statistical analysis (Aztekin et al., 2010), cluster analysis (Bencze et al., 2006; İlin 2016; Vanfretti and Farrokhabadi, 2013), and principle component analysis (PCA) (Blundell, Wittkowski et al., 2012; Lengnink and Prediger, 2003). These statistics provide investigator with multiple ways to explore the internal patterns of subject's cognitive

structures. İlin (2016) investigated a female novice teacher's knowledge of the qualities of an effective teacher. More specifically, the participant was asked to discuss nine persons, that is, three effective, three typical, and three ineffective teachers, respectively, in a semi-structured interview. The nine persons (who were given assumed names) were thus effectively treated as elements to elicit the teacher's constructs. A RG was then established using these elements and constructs to collect quantitative data. Afterwards, cluster analysis was applied to reveal the structure of the RG data, which helped the researcher explore the teacher's knowledge structure regarding the qualities of an effective teacher. Vanfretti and Farrokhabadi (2013) applied the RGT to investigate university students' opinions regarding their engineering curriculums. Nine elements that had the largest impact on the students' learning approaches were identified in the study, such as final exams, weekly tests, test solutions, and so on. As soon as the RG and the rating of the RG were completed, cluster analysis was applied to reveal the students' knowledge structures, which provided the researchers with insights to explain how the students saw their courses, as well as what modifications should be made to improve their learning. Like cluster analysis, PCA is a statistic analytical approach that has often been integrated into RG analysis to explore individuals' cognitive structures. The layout of PCA produces a 2-dimensional space in which all the elements and constructs are mapped according to the scores given to each pairing in the RG by a study's subjects. That is, the layout of PCA reveals the subjects' cognitive structures and implies how the subjects interpret the given topic (Luk and Shek, 2006; Ralley et al., 2009; Tan et al., 2013). Blundell et al. (2012) applied PCA of the RGT to investigate nursing staff members' attitudes toward their patients who have mental health problems. The elements set in the study consisted of the patients with various types of mental health problems, while the constructs consisted of the staff members' views of them. After a RG was built and the RG rating was completed, PCA was applied by the investigators. The layout of the PCA revealed every relationship among the elements and constructs on a 2-dimensional map, providing the investigators with evidence to explain the staff members' perceptions regarding their clients. A similar PCA approach was also applied by Partridge (2012) to explore staff members' experiences of emotional well-being in a pastoral secondary school. These authors reported that both cluster analysis and PCA provided highly valuable analytical results.

Identifying principles based on experts' knowledge

The participants in the studies utilizing RGT methodology provided as examples above share a common feature. That is, most of these participants were novices in the given field, such as students, patients, and novice teachers. We understand that the authors of these studies, then, were trying to understand the participants in their studies, in order, for example, to help them to solve their mental problems or obtain better knowledge and skills after instruction. In contrast, however, some researchers purposefully choose experts as the participants in their studies (Fischer et al., 2012; Gupta et al. 2010; Jordan and Persson, 2007; McGregor, 2014). These researchers are expected to identify principles or to construct a theory relevant to a given field based on these experts' abundant knowledge and experience. For example, Jordan and Persson (2007) invited 20 professionals (experts) from a variety of different professional backgrounds and a wide age range to participate in a study. These experts' thoughts on various types of technological products were collected through the triadic elicitation method. Four categories of the experts' thoughts were then clarified through follow-up content analysis. The results enabled the investigators to identify principles for the design of positive affective technological products. Gupta et al. (2012) identified expert opinions on factors influencing societal responses to developments and applications of nanotechnology. A number of experts from various professional fields, such as material science, polymer technology, cosmetics, food, and so on, were invited as participants. Their constructs were collected through structured interviews and then analyzed by PCA of the RGT, which enabled the authors to identify the relevant characteristics of nanotechnology with regard to its development and application. Generally, a main purpose of the integration of statistic analytic approaches in the data analysis of the RGT is to reduce the complexity of the RG data, which helps to reveal the internal structure of said RG data. Such approaches enable investigators to explore subjects' personal cognitive structures or identify important features among the collected constructs.

Making comparisons among constructs

Improving learning reflections

Alban-Metcalf (1997) reported that there are two approaches for applications of the triadic elicitation method: the static approach and the dynamic approach. The former approach elicits perceptions held by a subject at a specific point in time (e.g., Suto and Nadas, 2009), while the latter repeats the elicitation to indicate changes of perception over time (e.g., Ben-Zvi Assaraf and Orion, 2010). Thus, the dynamic approach is a kind of comparative approach used in analyzing subjects' cognitive structures. This approach has been widely used in research on education and educational psychology (Bezzi, 1996; Ben-Zvi Assaraf and Orion, 2010; Chitsabesan et al., 2006; Henze et al., 2007; Luk and Shek, 2006; Kuipers and Grice, 2009; Hopper, 2000; McGregor, 2014; Touw et al., 2015).

One reason for this widespread use is that such a comparative approach emphasizes subjects' learning and learning reflections. Bezzi (1996) applied the RGT to investigate students' perceptions of geology. Bezzi supplied the students with all the layouts of a cluster analysis. These layouts revealed the students' own cognitive structures and those of their peers, which enabled them to engage in reflections on how they perceived the given topic, what they knew, what they had experienced, and how they had changed after instruction. Moreover, students were also encouraged to identify similarities and differences between their own knowledge structures and those of others, communicate their understandings with others, and generate arguments for defending their positions. In Luk and Shek's (2006) study, changes in the self-identity systems of nineteen ex-mental patients before and after a holistic psychiatric rehabilitation program were investigated. To examine the changes, the study applied PCA and took the three most important elements (the ideal self at present, an ideal ex-mental patient, and an unsuccessful person) as reference points when the PCA layout was analyzed. Such a design and analytic strategy enabled the investigators to have specific targets to explore with regard to changes in the patients' self-identity systems, which helped the investigators, in turn, to know how to facilitate their patients in making improvements. Wu et al. (2011) developed a grid-oriented clinical learning program for nurse training. The program was integrated into mobile devices as a personal digital assistant, which enabled users to record what they saw during clinical diagnoses. Fundamentally, it enabled the users to engage in reflections by comparing their own observations across time. Tobacyk (1987) and Mayo (2004) investigated students' learning in a psychology history course with the RGT. In the grid rating phase, they requested that all the participants share, compare, and seek differences in their rating scores, discuss the reasons for each rating, and justify their scores using arguments. As Mayo (2004) pointed out, "the observed outcomes of the end-of-semester, whole-class discussion in the RG condition lend additional support to students' perceptions that RGT encouraged conceptual understanding and active involvement in learning" (p. 180). McGregor (2014) investigated differences in the auditory experiences of expert and non-expert listeners. To do so, McGregor developed a RG to collect quantitative data from both expert and non-expert listeners. Follow-up comparison analyses showed the percentage difference for each compared object. These results provided the researcher with evidence to explain what makes a listener an expert. The RGT supports subjects' learning reflection which is important in researching education and educational psychology. A researcher may request subjects to share their thinking about how to assign a rating during a grid rating activity in order to improve their learning reflection. Furthermore, it may also be appropriate to supply the subjects with the RGT analytic results regarding their own, their peers', and their instructors' cognitive structures to engage in reflection. These strategies reveal that the RGT is a method that could be applied appropriately in research on education and educational psychology.

Evaluation of contents and meanings of text data

Recent studies concerning text analysis have mainly dealt with the value of the contents and meanings conveyed by both the images and words of texts (Snyder and Broadway, 2004; Stern and Roseman, 2004). A number of studies adapted the RGT for this kind of analysis because of its systematic procedures for data collection and evaluation. Suto and Nadas (2009) applied the RGT to analyze the math and physics questions on past General Certificate of Secondary Education (GCSE) examinations. The focus of the analysis was to explore features which would yield differing marking accuracies among these questions in GCSE examinations. In the RGT setting, the elements consisted of questions included in the GCSE examinations, while the constructs consisted of comments obtained through the application of the triadic elicitation method with experienced examiners. Content analysis was then applied to explore the content of the collected comments. Then, the study identified a number of features of the exam questions that would affect a marker's marking accuracy. Greatorex (2001) applied the RGT to develop grade descriptions for an international economics syllabus. Two economics experts were invited to evaluate three scripts provided by three candidates with different degrees of mastery in economics. These scripts were treated as elements for use in the triadic elicitation method in order to collect these experts' explanations of what distinguishes performance at one level from performance at another. Follow-up content analysis enabled the study's author to construct a framework in which the knowledge and skills required for performance at each level of economics were described in detail. Hu et al. (2003) explored science curriculum components favored by high school students. Six components that were emphasized in a new biology curriculum were selected as elements of the RGT (e.g., problem solving skills, scientific concepts, social/ethical issues, and so on). Then, those elements were employed in the triadic elicitation method to collect student thoughts regarding their own comments, as well as the reasons for their preferences for those elements. Follow-up content analysis and descriptive statistics provided the researchers with evidence on the basis of which they could then provide suggestions for both the implementation of the current curriculum and the development of future science curriculums.

DISCUSSION

The RGT is a research method with mixed analysis

Table 1. A summary of information regarding the application of the RGT for each of the reviewed literature.

Authors(Year)	Participants	Topic	Purpose	Strategy of data collection	Strategy of data analysis
Tobacyk (1987)	College students	Education in psychology history	To promote students' leaning understanding through	Develop a RG to collect students' rating score.	Descriptive statistics
Bezzi(1996)	College students	Teaching and learning in geology	To explore students' cognitive structure regarding the geology	Triadic elicitation interviews	Cluster analysis Comparison analysis
Hopper(2000)	Pre-service teachers	Teacher education	To promote teacher's knowledge about effective teaching	Semi-structure interviews	Cluster analysis Content analysis
Hu et al (2003)	High school students	Textbook analysis	To explore components in a newly biology curriculum favored by students	Triadic elicitation interviews	Content analysis

techniques that has usually been used to elicit and interpret subjects' personal knowledge. As a researcher, it is important to know the pros and cons of the various applications of the RGT before using it. Past studies have reported some factors that might influence the reliability and validity of different applications of the RGT, such as the complexity of construct and element (Kelsall and Strongman, 1978; Keynan et al., 2014) and the prior knowledge of the participants (Caine and Smail, 1969; Lansdown, 1975). In some cases, the selected constructs may not be applicable to all the selected elements, which may cause the RG to fail to capture the subjects' inherent understanding (Vanfretti and Farrokhabadi, 2013; Suto and Nadas, 2009). To improve the reliability and validity of applications of the RGT, it is suggested that investigators take participants' opinions into account during the selection of elements and constructs in establishing a RG (Cohen et al., 2007; Keynan et al., 2014; Latta and Swigger, 1992). Moreover, RGs often cannot be used across individuals because the components (elements and constructs) of a RG usually come from a single person, such that a given RG is effectively private in nature. Such limitations can be resolved by establishing a universal/public RG in which all the components (elements and constructs) are collected through discussions involving all the participants (McGregor, 2014; Mayo, 2004; Tobacyk, 1987). This enables researchers to compare subjects' cognitive structures across individuals. Based on the summary of Table 1, it is no doubt that the RGT can be applied for various research purposes with regard to exploring subjects' cognitive structures. This does not mean, however, that the RGT can only be used to analyze a subject's personal knowledge. That is, there are a number of aspects contained in a single individual's cognitive structure, such as knowledge, attitudes, and aspects of various skills. Regrettably, however, few studies have applied the RGT to explore subjects' attitudes and skills (Guo et al., 2011). This could constitute a research gap that requires further investigations. Second, most of the studies we reviewed purposefully invited either students (a kind of novice) or experts to participate as per their research design. Few researchers selected subjects from different cultural backgrounds or with different levels of prior knowledge in order to explore their general understanding regarding a given issue (Kreber and Klampfleitner, 2012; Kuipers and Grice, 2009). Recently, however, the development of computer programs utilizing the RGT has made it easier to support these kinds of investigations, such as studies involving survey research and big data analytics.

Conclusion

Although the RGT is still not a dominant methodology in research on education and educational psychology, its applications in these fields thus far have been diverse. A basic strategy for using the RGT for data collection is the well-known triadic elicitation method, an interviewing technique that helps to elicit personal perceptions, beliefs, feelings, and attitudes towards a given issue. In our literature review, we found that some researchers selected novices, such as pre-service teachers, students, or patients, as the participants in their studies because they intended to understand these novices' learning problems (or misconceptions) to help them solve those problems, and improve their learning. In other cases, researchers selected experts as study participants in order to explore the content of their knowledge and experiences, which were typically regarded by the researchers as resources for identifying principles and constructing theories. To analyze collected constructs, the RGT allows integrations of both

Table 1 Cont. A summary of information regarding the application of the RGT for each of the reviewed literature.

Authors(Year)	Participants	Topic	Purpose	Strategy of data collection	Strategy of data analysis
Lengnink&Prediger(2003)	Pre-service teachers	Teacher education	To explore teacher students' individual conceptions about learning and teaching mathematics.	Triadic elicitation interviews	Line diagram analysis
Mayo(2004)	College freshmen and sophomores	Teaching in psychology history	To promote students' leaning understanding	Develop a RG to collect students' rating score	Descriptive statistics
Bencze, Bowen and Alsop (2006)	Secondary school teachers	Science teaching	To explore relationships between teachers' conceptions about science and their strategies for teaching science	Semi-structure interviews	Cluster analysis
Luk and Shek(2006)	Patients with ex-mental problem	Psychiatric rehabilitation and holistic care	To promote personal changes of patients after attending a psychiatric rehabilitation program	Triadic elicitation interviews	Principal components analysis
Chitsabesan et al (2006)	Teachers in medical school	Clinical teaching	To explore relationships between teachers' high-inference teaching characteristics and the associated low inference teaching behaviors	Triadic elicitation interviews	Content analysis
Jordan and Persson (2007)	Professionals from a variety of different professional backgrounds	People and products	To investigated the issues that people identify when thinking about various types of products	Triadic elicitation interview	Content analysis
Henze et al (2007)	Science teachers	Science teaching	To explore the improvement of teachers' knowledge about teaching models and modeling	Semi-structure interviews	Cluster analysis Comparison analysis (pretest-posttest design)
Kuipers and Grice (2009)	Novice and expert occupational therapists	clinical reasoning	To promote occupational therapists' capacity of clinical reasoning	Triadic elicitation interviews	Comparison analysis (across individuals)
Ralley et al (2009)	nursing staffs	Nurse training	exploring staff beliefs about clients with mental health problem	Triadic elicitation interviews	Principal components analysis Comparison analysis (across individuals)
Suto and Nadas(2009)	experienced examiners	Math and physics education	To identify question features in GCSE examinations that would yield differing marking accuracies	Triadic elicitation interviews	Descriptive statistics Content analysis

Table 1 Cont. A summary of information regarding the application of the RGT for each of the reviewed literature.

Authors(Year)	Participants	Topic	Purpose	Strategy of data collection	Strategy of data analysis
Ben-ZviAssarafand Orion (2010)	elementary students	Science learning	to investigate the change of students' science concept before and after instruction	Triadic elicitation interviews	Content analysis Descriptive statistics Comparison analysis (pretest-posttest design)
Guo et al (2011)	university students'	computers and education	to explore attitude of using computer-mediated communication media	Triadic elicitation interviews	content analysis and cluster analysis
Wu et al. (2011)	Undergraduate students	Nurse Education	To improve students' nursing knowledge through a clinical mobile learning system	Students record symptoms and organize their nursing knowledge to construct their own repertory grid during clinical observations	Descriptive statistics t-test analysis
Greatorex (2001)	Economics experts	Economic education	To develop a grade descriptors to generate assessment rubrics, assignment-specific marking schemes and marking criteria	Triadic elicitation interviews	content analysis
Partridge (2012)	Pastoral staffs	Mental health	To explore staff's experiences of emotional well-being	Triadic elicitation interviews	Principal components analysis
Gupta et al. (2012)	Experts from a variety of different backgrounds	the applications of nanotechnology	To explore experts' opinions and knowledge regarding applications of nanotechnology	Triadic elicitation interviews	Principal components analysis
Blundell et al. (2012)	Nursing staffs	Clinical Psychology	To investigate nursing staffs' attitudes on patients with mental health problems	Triadic elicitation interviews	Principal components analysis Comparison analysis (across individuals)
Kreber and Klampfleitner (2012)	University lecturers	University education	To explore teachers' conceptions regarding the authenticity in teaching	Triadic elicitation interviews	Content analysis
Vanfretti and Farrokhabadi (2013)	university students	University education	To investigate students' opinions on their course of engineering	Triadic elicitation interviews	Principal components analysis
Tan et al. (2013)	Ninth grade students and their English teachers	Language education	To explore acceptance of using digital pen during reading activity	Triadic elicitation interviews	Principal components analysis

Table 1 Cont. A summary of information regarding the application of the RGT for each of the reviewed literature.

Authors(Year)	Participants	Topic	Purpose	Strategy of data collection	Strategy of data analysis
Ben-ZviAssaraf et al. (2013)	Tenth grade students	Students' science learning	To explore students' knowledge on the human body system	Triadic elicitation interviews	Content analysis
McGregor (2014)	Designers and listeners	Listening experience	To compare the listening experiences between non-experts and the designers	Triadic elicitation interviews	Cluster analysis Comparison analysis
Touw et al. (2015)	Student teachers	Teacher education	To explore student teachers' constructs about their students	Triadic elicitation interviews	Content analysis
İlin (2016)	A female novice teacher	Teacher education	To investigate teacher's conceptualization of an effective teacher	Triadic elicitation interviews	Cluster analysis

qualitative and quantitative analytical approaches. Such strategies help to reveal the internal relationships among subjects' personal constructs in a systematic way. Another feature of the RGT is that it can be applied in comparison analyses. Most of purposes of the studies that we reviewed involving comparison analysis were related to the promotion of subjects' learning and learning reflections. Strategically, investigators may supply subjects with their own and their peers' RGT layouts in order to improve their self-awareness. Comparison analysis could also be used in the context of text analyses, including analyses of textbooks, educational objectives, questions on examinations, and so on. It is expected that the model presented in this review can provide researchers with a new vision of how to develop research designs that are appropriate for applications of the RGT.

REFERENCES

Alban-Metcalf RJ (1997). Repertory grid technique. In J. P. Keeves (Ed.), Educational research, methodology and measurement: An international handbook (2nd edition) (pp. 315-318). Oxford: Elsevier Science Ltd.

Adams-Webber JR (1979). Personal construct theory: Concepts and applications. New York: Wiley.

Aztekin S, Arikan A, Sririman B (2010). The constructs of PhD students about infinity: An application of repertory grids. The Montana Mathematical Enthusiast, 7(1):149-174.

Ben-Zvi AO, Orion N (2005). Development of system thinking skills in the context of earth system education. J. Res. in Sci. Teaching, 42(5), 518-560.

Ben-Zvi AO, Orion N (2010). Systems thinking skills at the elementary school level. J. Res. in Sci. Teaching, 47(5):540-563.

Ben-Zvi AO, Dodick J, Tripto, J (2012). High school students' understanding of the human body system. Research in Science Education 43:33-56.

Bezzi A (1996). Use of repertory grids in facilitating knowledge construction and reconstruction in geology. J. Res. in Sci. Teaching, 33(2):179-204.

Bezzi A (1997). The influence of Geology teaching on the image of geosciences. In H. Wang, D. F.Branagan, Z. Ouyang, and X. Wang (Eds.), Proceedings of the 30th International Geology Congress,Beijing, PRC 26:123-138. Utrecht: VSP.

Bezzi A (1999). What is this thing called geoscience? Epistemological dimensions elicited with the repertory grid and their implications for scientific literacy. Science Education 83(6): 675-700.

Bencze JL, Bowen GM, Alsop S (2006). Teachers' tendencies to promote student-led science projects: associations with their views about science. Science Education 90(3): 400-419.

Blundell J, Wittkowski A, Wieck A, Hare DJ (2012). Using the repertory grid technique to examine nursing staff's construal of mothers with mental health problems. Clinical Psychology and Psychotherapy 19:
260-269

Borell K, Espwall M, Pryce J, Brenner SO (2003). The repertory grid technique in social work research, practice, and education. Qualitative Social Work, 2(4):477-491.

Boyle TA (2005). Improving team performance using repertory grids. Team Performance Management 11 (56):179-187.

Bradshaw JM, Ford KM, Adams-Webber JR, Boose JH (1993). Beyond the repertory grid: New approaches to constructivist knowledge acquisition tool development. Inter. J. Intelligent Systems 8:287-333.

Chitsabesan P, Corbett S, Walker L, Spencer J, Barton JR (2006). Describing clinical teachers' characteristics and behaviors using critical incidents and repertory grids. Medical Education, 40(7):645-653.

Cohen L, Manion L, Morrison K (2007). Research methods in education (6th Edition). London: Routledge.

Corporaal AH (1991). Repertory grid research into cognitions of prospective primary school teachers. Teaching and Teacher Education 7: 315-329.

Edwards HM, Mc Donald S, Young SM (2009). The repertory grid technique: Its place in empirical software engineering research. Information and Software Technology 51:785-798.

Epting FR, Suchman DI, Nickeson CJ (1971). An evaluation of elicitation procedures for personal constructs. British J. Psy. 62:513–517.

Easterby-Smith M (1980). The design, analysis and interpretation of repertory grids. Inter. J. Man-Machine Studies 13:3-24.

Fetherstonhaugh T (1994). Using the repertory grid to probe students' ideas about energy. Research in Science and Technological Education 12:117-127.

Fjeld SP, Landfield AW (1961). Personal construct theory consistency. Psychological Reports, 8:127-129.

Fransella F, Bannister D (1977). A manual for repertory grid technique.London: Academic Press.

Fransella F, Bell RC, Bannister D (2004). A manual for repertory grid technique (2nd edition). Chichester, UK: John Wiley and Sons.

Gupta N, Fischer AR, Van der Lans IA, Frewer LJ (2012). Factors influencing societal response of nanotechnology: An expert stakeholder analysis. J. Nanoparticle Res. 14(5):1-15.
Guo Z, Lu X, Li Y, Li Y (2011). A framework of students' reasons for using CMC media in learning contexts: A structural approach. J. American Society for Info. Sci. Technol. 62:2182-2200.
Greatorex, J. (2001). Making the grade - how question choice and type affect the development of grade descriptors. Educational Studies, 27(4):451-464.
Haney W, Russell M, Gulek C, Fierros E (1998). Drawing on education: Using student drawings to promote middle school improvement. Schools in the Middle 7(3): 38- 43.
Happs JC, Stead K (1989). Using the repertory grid as a complementary probe in eliciting student understanding and attitudes toward science. Research in Science and Technological Education 7:207-220.
Henze I, Van DJ, Verloop N (2007). The change of science teachers' personal knowledge about teaching models and modeling in the context of science education reform. Inter. J. Sci. Edu. 29(15):1819-1846.
Hopper TF (2000). Student teachers' transcending the limits of their past: Repertory grid framing narratives for learning to teach. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans LA.
Hu R, Chang WH, Lin CY (2003). Science curriculum components favored by high school students in Taiwan. J. Bio. Edu. 37(4):171-175.
İlin G (2016). Effects of doctorate program on a novice teacher's conceptualization of an effective teacher: A case study. Educational Research and Reviews, 11(7):411-419.
Jordan PW, Persson S (2007). Exploring users' product constructs: How people think about different types of product. CoDesign, 3:97-106.
Jankowicz D (2004). The easy guide to repertory grids. Chichester, West Sussex, England: J Wiley.
Kelly GA (1955). The psychology of personal constructs. New York: Norton.
Keynan A, Ben-Zvi AO, Goldman D (2014). The repertory grid as a tool for evaluating the development of students' ecological system thinking abilities. Studies in Educational Evaluation, 41, 90-105.
Kington A, Sammons, P., Day, C. and Regan, E. (2011) Stories and Statistics: Describing a mixed methods study of effective classroom practice. J. Mixed Methods Res. 5 (2):103-125.
Kreber C, Klampfleitner M (2012). Construing the meaning of authenticity in university teaching: Comparing explicit to implicit theories. J. Constructivist Psychol. 25, 34-69.
Kuipers K, Grice JW (2009). The structure of novice and expert occupational therapists' clinical reasoning before and after exposure to a domain-specific protocol. Australian Occupational Therapy J. 56:418-427.
Lansdown R (1975). A reliability study of the 8 x 8 repertory grid. J. Association Edu. Psychol. 3:24-25.
Lemke JL (1990). Talking science: Language, learning, and values. Ñorwood, NJ: Ablex.
Lengnink K, Prediger S (2003). Development of personal constructs about mathematical tasks-a qualitative study using the repertory gird methodology. In Pateman NA, Dougherty BJ, Zilliox JT (Eds.), Proceedings of the 27th PME International Conference. (pp.39-46). Hawaii.
Lin YR, Hung JF, Huang KY (2013). Applying repertory grid to assess inexperienced and experienced teachers' teaching of argumentation. The 3rd Biennial Conference of East-Asian Association for Science Education. Hong Kong.
Lin CY, Hu R, Changlai ML (2005). Science curriculum components favored by Taiwanese biology teachers. Research in Science Education 35:269-280.
Luk AL, Shek D (2006). Perceived personal changes in Chinese ex-mental patients attending a holistic psychiatric rehabilitation program. Social behavior and personality 34(8):939-954.
Mayo JA (2004). Repertory grid as a means to compare and contrast developmental theorists. Teaching of Psychology 31:178-180.
McMillan W(2007). "Then you get a teacher"-Guidelines for excellence in teaching. Medical Teacher 29: 209-217.
McGregor I (2014). Comparing designers' and listeners' experiences. Ai and Society 29: 473-483.
Miles MB, Huberman AM (1994). Qualitative data analysis: An expanded sourcebook (2nd edition). Thousand Oaks, CA: Sage Publications.
Partridge K (2012). Exploring pastoral staff's experience of their own emotional well-being in a secondary school. Educational and Child Psychology 29:121-132.
Ralley C, Allott R, Hare DJ, Wittkowski A (2009). The use of the repertory grid technique to examine staff beliefs about clients with dual diagnosis. Clinical Psychology and Psychotherapy, 16(2):148-158.
Shaw MLG, Brian RG (1992). Kelly's "geometry of psychological space" and its significance for cognitive modeling, The New Psychologist 10: 23-31.
Shaw MLG, Gaines BR (1996). Web Grid: knowledge elicitation and modeling on the web. In H. Maurer (Ed.), Proceedings of WebNet96 (pp. 425-432). Charlottesville, VA: Association for the Advancement of Computing in Education.
Snyder VL, Broadway FS (2004). Queering high school biology textbooks. J. Res. in Sci, Teaching 41(6):617-636.
Solas J. (1992). Investigating teacher and student thinking about the process of teaching and learning using autobiography and repertory grid. Review of Educational Research 62:205-225.
Stern L, and Roseman JE (2004). Can middle-school science textbooks help students learn important ideas? Findings from Project 2061's curriculum evaluation study: Life science. J. Res. in Sci. Teaching, 41(6):538-568.
Strauss A (1987). Qualitative analysis for social scientists. Cambridge: Cambridge University Press.
Suto WMI, Nadas R (2009). Why are some GCSE examination questions harder to mark accurately than others? Using Kelly's repertory grid technique to identify relevant question features. Research Papers in Education, 24(3):335-377.
Tan CC, Chen CM, Lee HM (2013). Using a paper-based digital pen for supporting English courses in regular classrooms to improve reading fluency. International Journal of Humanities and Arts Computing, 7, 234-246.
Tobacy JJ (1987). Using personal construct theory in teaching history and systems of psychology. Teaching of Psychology 14(2):111-12.
Touw HMF, Meijer PC, Wubbels T (2015). Using Kelly's theory to explore student teachers' constructs about their pupils. Personal Construct Theory and Practice, 12:1-14.
Vanfrett L, Farrokhabadi M(2013). Evaluating constructive alignment theory implementation in a power systems analysis course through repertory grids. IEEE on Transactions education 56:443-452.
Van KCA, Ponte P, Verloop N (2010). How to conduct research on the inherent moral significance of teaching: A phenomenological elaboration of the standard repertory grid application. Teaching and Teacher Education, 26:1553-1562.
Van KCA, Ponte P, Verloop N (2013). How do teachers legitimize their classroom interactions in terms of educational values and ideals? Teachers and Teaching: Theory and Practice, 19(6):610-633.
Wu PH, Hwang GJ, Tsai CC, Chen YC, Huang YM. (2011). A pilot study on conducting mobile learning activities for clinical nursing courses based on the repertory grid approach. Nurse Education Today 31(8):e8-e15.