Evaluation and Program Planning xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Evaluation and Program Planning

journal homepage: www.elsevier.com/locate/evalprogplan

Concept mapping as an approach for expert-guided model building: The example of health literacy

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ARTICLE INFO

Article history:
Received 20 August 2016
Accepted 7 October 2016
Available online xxx

Keywords:
Health literacy
Model building
Structural equation modeling

ABSTRACT

Concept mapping served as the starting point for the aim of capturing the comprehensive structure of the construct of 'health literacy.' Ideas about health literacy were generated by 99 experts and resulted in 105 statements that were subsequently organized by 27 experts in an unstructured card sorting. Multidimensional scaling was applied to the sorting data and a two and three-dimensional solution was computed. The three dimensional solution was used in subsequent cluster analysis and resulted in a concept map of nine "clusters": (1) self-regulation, (2) self-perception, (3) proactive approach to health, (4) basic literacy and numeracy skills, (5) information appraisal, (6) information search, (7) health care system knowledge and acting, (8) communication and cooperation, and (9) beneficial personality traits. Subsequently, this concept map served as a starting point for developing a "qualitative" structural model of health literacy and a questionnaire for the measurement of health literacy. On the basis of questionnaire data, a "quantitative" structural model was created by first applying exploratory factor analyses (EFA) and then cross-validating the model with confirmatory factor analyses (CFA). Concept mapping proved to be a highly valuable tool for the process of model building up to translational research in the "real world".

1. Introduction

In recent years, taking care of one's health has been increasingly associated with shifting the responsibility from the individual as a passive recipient of medical advice to the individual as active co-producer of health (Fisher, Dixon, & Honeyman, 2005). This shift has led to an increased need for health-related information on the one hand and a flood of this type of information on the other. In order to cope with this shift, individuals need to have the skills to use health information adequately; they must have the skills to find, understand and then process health information that corresponds to their needs (Norman & Skinner, 2006a, 2006b). To more specifically describe the skills and abilities individuals need to use health information, the concept of health literacy was introduced in the last decade (see, for example, Kickbusch, 2001; Nutbeam, 2000) and has increasingly received the attention in both science and politics (Paasche-Orlow, McCaffery, & Wolf, 2009; Soellner, Huber, & Reder, 2014).

In a general sense, health literacy is a set of cognitive, social and motivational skills that enable people "to gain access to, understand and use information in ways which promote and maintain good health" (Nutbeam, 1998, p.357). At a more detailed level, many different conceptualizations of the term health literacy exist (Soellner, Huber, Lenartz, & Rudinger, 2009). These conceptualizations overlap to some extent but also differ such that no common model of health literacy emerged, though these different approaches do tend to align with one of the two major paradigms (Pleasant & Kuruvilla, 2008). The first, a clinical approach, defines health literacy as "the ability to read and comprehend prescription bottles, appointment slips, and the other essential health-related materials required to successfully function as a patient" (American Medical Association 1999, p. 552). The second, a public health approach, encompasses the clinical definition but is more expansive and includes an active and constructive handling of health related information (Nutbeam, 2000). The latter approach was the focus of this project.

In the public health approach to health literacy, Nutbeam (2000) suggested a bottom-up model with three levels consisting

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http://dx.doi.org/10.1016/j.evalprogplan.2016.10.007
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Table 1
Demographic characteristics and response rates of healthcare experts.

Task	Participation			Age				Gender		Professional Background				Work experience		
	Request	Response	Rate	Mean	Min	Max	SD	M	F	Psych	Medical	Educator	other	Science	Patient care	Other
Brainstorming	243	99	40.7%	45	28	69	9.5	52.3%	47.7%	48.8%	19.8%	14.0%	17.4%	55.8%	19.8%	24.4%
Sorting	48	27	56.3%	40	25	57	7.9	51.9%	44.4%[a]	81.5%	7.4%	7.4%	3.7%	63.0%	22.2%	14.8%
Rating	27	20	74.1%	39	25	49	6.5	55.0%	45.0%	75.0%	10.0%	10.0%	5.0%	55.0%	25.0%	20.%

[a] 1 data point was missing.

of functional, communicative/interactive and critical health literacy. In the first level, basic reading, writing and literacy skills as well as knowledge of health systems are necessary to understand health related information and transfer it to action. Interactive literacy, the second level, comprises social skills that enable the individual to actively take part in the health-related environment and derive meaning from different forms of communication. Third, critical health literacy is the ability to critically question health-related information, the health care system in general and to then use this information to actively address the social, economic and environmental determinants of health.

A concern is that among the multiple conceptual approaches, including the Nutbeam model, few were derived empirically or have demonstrated validity. For the most part, literature reviews integrating parts of theoretical approaches or unsystematic observations formed the basis for developing these models. More recently, efforts to better define and measure health literacy have emerged. These efforts include a focus on the measurement of single components of health literacy, such as communication (Grice et al., 2013) or verbal exchange health literacy (Harrington & Valerio, 2014), while another proposes a comprehensive model of health literacy as a composite of cognitive abilities, academic skills and health knowledge (Ownby, Acevedo, Waldrop-Valverde, Jacobs, & Caballero, 2014). In a broader approach, Jordan et al. (2013) developed a Health Literacy Management Scale (HeLMS) on the basis of interviews and concept mapping, resulting in the first multi-dimensional measure of health literacy from a patient perspective. The HeLMS identified eight domains of health literacy that were addressed by 29 items. While the HeLMS advanced measuring and thus understanding of health literacy, a structural model of its components is still needed that describes the abilities and skills necessary to decide and act in a way that promotes one's own health (Soellner et al., 2009).

This research project "Gesundheitskompetenz- Modellbildung und Validierung [Health literacy – model building and validation]"aimed to develop a comprehensive model of health literacy. The objectives of this study were to develop a structural model of health literacy, develop a measurement instrument based on the model, and then validate the structural model. Relying on healthcare experts for input, concept mapping methodology was used as a basis to build a "qualitative" structural model of health literacy and to create a measurement instrument. Based on the questionnaire data a quantitative model was developed using structural equation modeling. This study serves as an example to demonstrate the use of concept mapping for theory building, measurement development and follow-on applications.

2. Concept mapping methods

2.1. Concept mapping

The procedure of concept mapping is described in detail elsewhere (see for example, (Kane & Trochim, 2007; Trochim & McLinden, 2016; Trochim, 1989). Beginning with brainstorming, ideas are gathered regarding the issue under study; subsequently, each study participant structures the ideas, first by sorting the ideas into groups of similar ideas and then by rating the ideas. Data analysis consists of a multidimensional scaling (MDS) of the sorting data to compute the location of each idea on a map and then using cluster analysis to partition the map of ideas into a smaller number of clusters or concepts that share a conceptually similar meaning. Analysis of the rating data involved computing descriptive statistics. Data collection for sorting and rating were, for the most part, collected online using CS Global 4.0 platform (Concept Systems©); several participants completed tasks offline and were provided with a paper version of the data collection processes. Data were analyzed using PROXSCAL version of MDS to create the map and hierarchical cluster analysis to partition the map; analyses were conducted with SPSS 15.0.

2.2. Sample

The aim was to create an *expert*-guided model building in health literacy; experts were defined as being all persons who work as professionals in the health sector as well as scientists in the domain of competence measurement. Experts from Germany and German speaking countries (N = 243) were invited to participate in the data collection process and 99 (40.7%) participated in the first phase, the brainstorming. Subsequently, 48 experts expressed their willingness to take part in the sorting task and 27 completed the sorting task. Twenty of the 27 experts from the sorting task participated in the final task, rating each of the statements. The makeup of the groups with respect to age, gender, and professional activity remained similar across the data collections tasks and demographic details are provided in Table 1. Prior to beginning the first data collection step, brainstorming, participants provided their informed consent to the study.

2.3. Data collection

2.3.1. Brainstorming

In the brainstorming task, participants were presented with a focus question and asked to generate statements related to that question, specifically, "*Which skills and abilities do people need in order to act in ways that are beneficial for their health and well-being concerning everyday life as well as interacting with the health care system*?" Experts worked individually to brainstorm responses to this focus prompt. Brainstorming was done on an internet platform (CS Global 4.0) for all but two participants who worked offline and were provided with printed material.[1] Brainstorming was open for two weeks and during that time, 244 statements were produced.

2.3.2. Editing statements

Editing was necessary to manage the response burden for the remaining data collection tasks of sorting and rating and to ensure

[1] All materials were in German but and were translated into English by the authors solely for this paper.

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the clarity of the statements. The specific content of statements was not revised in order to avoid changing the meaning of the statement. Some statements contained multiple ideas and these statements were split into separate statements; the result was a final set of 382 statements. The response burden for the sorting task can be high and to manage the level of effort required, a typical concept mapping study is limited to about one hundred statements (Kane &Trochim, 2007). In a final editing step, statements were eliminated based on several criteria. A large dataset of ideas will typically contain multiple statements that express the same idea in the same or slightly different words; not all instances of an idea are necessary and redundant statements were eliminated. In this project the focus was on abilities, skills, and competencies; statements were eliminated if the statement referred to 'intelligence' or 'cognitive' capacity to understand the health system. Intelligence by definition is not a competence (Weinert, 2001) and was not considered in this study. Cognitive competence is an umbrella term comprising many more specific statements, so general statements of this type were eliminated. Decisions to delete statements were made by the research group (n = 4) and required consensus and, if there was no consensus, the statement was retained. At the conclusion of the editing process, 105 statements remained and were used as input for the subsequent sorting and rating task.

2.3.3. Sorting

Participants for the sorting task were recruited from the original sample, but due to willingness to participate being very low, additional experts from the domain of health and health science who had not previously participated in the study were invited to participate. Forty-eight individuals confirmed their willingness to take part and 28 completed the sorting (58.3%). Eleven out of the 27 participants completed the sorting online and 16 by sorting index cards manually. Data from one person who did not appropriately complete this task was excluded from analyses. Participants were instructed to sort the statements into categories or themes in a way that made sense to them, to create multiple categories, to name the category and finally, to not create a miscellaneous category. In the latter instance if a statement was not related to any other statements, participants are instructed to create a category with a single statement. The number of categories formed by the experts ranged from four to 25 categories (M = 12.07; SD = 6.13).

2.3.4. Rating

As the sorting task was time demanding (45–60 min), rating was conducted separately from the sorting task. Participants (N = 27) were invited to rate the statements and 20 of the 27 agreed to participate. Participants were asked to rate all statements concerning relevance to the focus question. Response options for the rating ranged from one (not relevant) to five (highly relevant).

3. Concept mapping results

3.1. Multidimensional scaling

Each person's sorted data results in a similarity matrix that represents the match of each statement with each other statement. Summing these individual matrices results in a group similarity matrix that represents the similarities of the statements across all participants. In a subsequent step, the group similarity matrix was analyzed via nonmetric multidimensional scaling (MDS), creating a 2- and 3-dimensional solution. MDS produces a stress index that serves as an indicator of the goodness of fit of the different MDS-solutions; stress varies between zero and one with lower values indicating better fit. The 2-dimensional solution resulted in a stress score of 0.31 (Kruskal, 1964), the 3-dimensional solution resulted in a stress score of 0.12 and thus was an improvement over the 2-dimensional solution. The 3-dimensional stress score is below and the 2-dimensonsal stress is within one standard deviation of the average stress value of 0.285 (SD = 0.04) for concept mapping studies as estimated in a meta-analysis by Torchim (see Kane & Trochim, 2007) and in a pooled study analysis by Rosas and Kane (2012) with an average stress value of 0.28 (SD = 0.04; range: 0.17–0.34). Thus, both models were considered as sufficiently valid; given the better fit of the 3-dimensional solution, further analysis was done with this solution.

3.2. Hierarchical cluster analysis

Based on the 3-dimensional multidimensional scaling model, hierarchical cluster analysis was applied to the map using average linkage algorithm. Since cluster analysis is a heuristic tool, no distinct mathematical criterion to judge the appropriate number of clusters exists and deciding on the appropriate cluster solution requires judgment. The decision regarding how many clusters should be selected was made by the research group taking into account content-related and theoretical considerations as well as

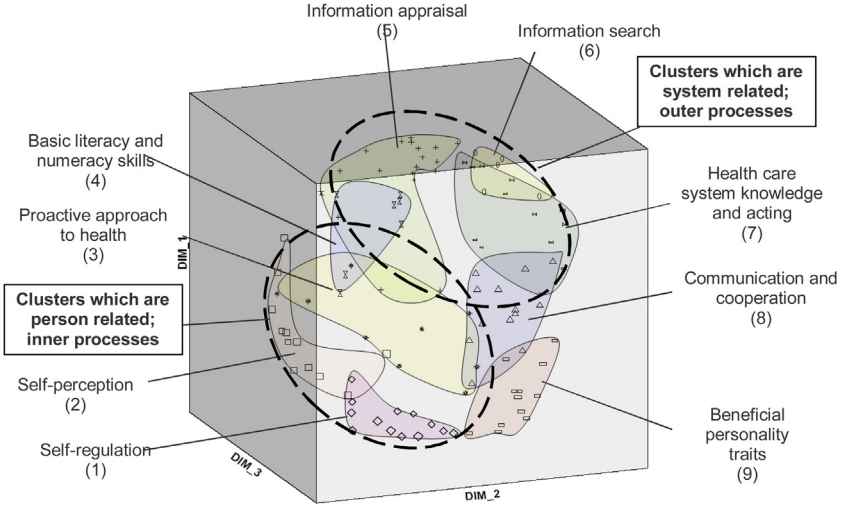

Fig. 1. Three-dimensional concept map with nine clusters and illustrating thematic regions of the map.

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Table 2
Nine cluster solution of the hierarchical cluster analysis on the 3-dimensional MDS with statements.

Cluster- number	*Statement*	*Cluster Name*
1	Ability to adapt expectations to given situations	Self-regulation
	Ability to refrain from personal problems	
	Ability to relax	
	Realization that one does not need to function all the time	
	Ability to keep a balance between work and recreation, e.g. work-life-balance	
	Ability to rely on oneself and upon one's own assessment/evaluation	
	Patience to care for one's own health	
	The ability to self-regulate oneself and the adequate strategies at one's command	
	Ability to deal with stressful and frustrating experiences	
	Ability to protect oneself	
	Discipline and self-control	
	Ability to control needs and impulses	
	Capacity for delayed gratification	
2	Self-perception	Self-perception
	Introspective access to one's own needs and feelings	
	Self-reflection	
	Realistic evaluation of ones strengths and weaknesses of body and mind	
	Awareness of one's body	
	The right balance between autonomy and compliance	
	Ability to look after resources for life, with oneself and others, especially in difficult circumstances	
	Realization and acceptance of illnesses	
	Ability to accept and appreciate oneself and one's own body	
	An understanding, that mental health is highly related to physiological health	
	Ability to perceive a connection between one's own behaviour and one's health status	
	Attitude to take bodily signals serious	
	High sensitivity with respect to the functioning of the own health	
3	Ability to decide whether it is necessary to see a doctor in a given situation and or not	Proactive approach to health
	Ability to see health as a goal that needs to be approached actively	
	Ability to assess on the adequacy of existing standards and the capability to set once own standards, if necessary	
	Ability to act thoughtfully/with foresight i.e. to plan, implement and reflect one's own behaviour	
	Persuasion that one is able to achieve one's aims and to self-reliant even in difficult situations	
	Ability to take responsibility for one's own health and well-being	
	To be able to master challenges deriving from impairments of health	
	Ability to distance suggestions of disease and stigmata	
4	Knowledge of terms and expressions to describe the body	Basic literacy and numeracy skills
	Skills in expressing and understanding of verbal information	
	Appropriate reading and writing skills	
	Broad general education	
	Basic math skills	
	Ability to describe one's own inner states, moods and needs	
	Ability to verbally express physical experiences	
5	Power of judgement	Information appraisal
	Ability to distinguish between more or less important topics	
	Ability to assess health risks realistically	
	Ability to differentiate associative and causal relationships, concerning diseases	
	Comprehension of biological processes and body functions	
	Knowledge about health relevant behaviours and healthy lifestyle	
	Basic knowledge about physical and mental health and illness; e.g. good general medical knowledge	
	Ability to reflect chances and limitations of medical science and health science	
	Ability to verify statements and information of health service providers on one's own rational and understanding	
	Ability to assess risk information's given by physicians, the industry, public media or politics	
	Ability to evaluate the importance of health promotion activities	
	Ability to critically distinguish between advertisement and serious information	
	Ability to critically deliberate diagnostic and therapeutic offers	
	To be able to critically examine health related information's	
	Ability to evaluate relevant information on health topics	
	Ability to construe scientific studies and to assess the content of a study respectively	
	Ability to understand health related information	
	Ability to understand results from medical tests	
	Ability to understand scientific information and to reconstruct scientific processes	
	Understand and integrate pertinent information, even if they are complex and contradictory	
6	Skills in dealing with new media like Internet, telephone e.g.	Information search
	Willingness to contact health service providers like physicians, nurses, counsellors etc.	
	Ability to find independent valid information, if necessary	
	Open minded dealing with new information on the health sector	
	Ability to ask providers of health related services competent questions for informed decision making.	
7	Ability to withdraw from the system	Health care system knowledge and acting
	Knowledge of rights and chances within the health care system and the ability to claim for them if necessary	

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Table 2 (*Continued*)

Cluster- number	*Statement*	*Cluster Name*
	Ability to use existing resources of the health care system	
	Ability to accept available offers for counselling and health prevention.	
	Have experience with the health care system and in dealing with the persons involved	
	Perseverance in obtaining information	
	Proficiency on basic structures of the health care system	
	Ability to see trough hidden interests of persons or institutions	
	Knowledge on which institutions provide valid information and the ability to use scientific information	
	Knowledge of who authorizes medical drugs and under which conditions these are authorized	
	Ability to consider context information when considering opinions given by experts	
	Acceptance of the limitations of what the health care system can do	
	Ability to bring health related information into action	
8	To be able to delegate tasks and responsibilities and not to carry everything by oneself	Communication and cooperation
	Ability to speak for oneself towards experts, institutions and authorities and assert oneself	
	The ability and willingness to maintain relationships, networking with and for others	
	Interpersonal skills to talk to others about oneself and one's health concerns	
	Willingness to communicate	
	Negotiation skills	
	Ability to achieve the satisfaction of personal needs in a social acceptable way	
	The ability to listen to others	
	Social competence	
	Ability to adjust to others, empathy and sensitivity	
	Ability to cultivate confining partnerships	
	Teamwork	
	Constructive dealing with conflicts	
9	Open-mindedness	Beneficial personality traits
	Tolerance	
	Ability to appear competent and self-confident	
	Willingness to change	
	Ability to behave perseveringly and persistency	
	Self-confidence	
	Problem solving skills	
	Calmness and serenity	
	Proactivity	
	Curiosity	
	Optimism	
	Positive attitude towards live	
	Constitutional competence	

being guided by reference to the dendrograms of the cluster analysis (see Jackson & Trochim, 2002). A nine-cluster solution was chosen and a label was added to each cluster to describe the concept or theme expressed by the statements in each cluster. The concept map included the following clusters: (1) self-regulation, (2) self-perception, (3) proactive approach to health, (4) basic literacy and numeracy skills, (5) information appraisal, (6) information search, (7) health care system knowledge and acting, (8) communication and cooperation, and (9) beneficial personality traits (Fig. 1). A complete list of statements associated with their cluster membership is provided in Table 2.

3.3. Ratings

The cluster mean ratings provide information on the relative importance of the cluster and are shown in Table 3. All clusters achieved mean ratings above three, meaning that all clusters were perceived as rather relevant to the construct of health literacy. Across all statements, the mean was 3.72 (min. 2.00, max. 4.65, SD = 0.56) and indicates that the statements were generally viewed as relevant to the construct of health literacy. Specific to the aim of developing and validating a structural model of health literacy, the ratings were taken as evidence that the concept map was a sound basis for next steps in the development of a health literacy model.

3.4. Interpreting meaning

Distance on a concept map is similar to the way that distance has meaning on a geographic representation in a map (see, for example, Borg, Groenen, & Mair, 2013; Trochim, Marcus, Mâsse, Moser, & Weld, 2008). In this case, proximity implies conceptual similarity and increasing distance implies conceptual difference, as a result, clusters lying close to each other have more in common than clusters lying more distant from each other: For example, in Fig. 1, the three clusters in the lower left area of the cube, self-regulation (1), self-perception (2) and proactive approach to health (3). While distinct in some ways these clusters have shared meaning by representing a person's internal processes in the sense of a person's ability to deal with the preservation and protection of one's health. This part of the concept-model fits with existing theoretical and empirical considerations regarding self-regulation (see for example, Zimmerman, 2005). Farther away from the internal processes, the clusters information appraisal (5), information search (6), and health care system knowledge and acting (7) constitute a region that describes skills and abilities necessary to act successfully in the health care system. Inner/personal and outer/systemic aspects of a person's handling of health related topics are regions of the map that are opposite to each other. In between there are clusters that can be seen as mediating between these inner and outer aspects of life, that is, communication and cooperation (8) and basic literacy and numeracy skills (4). Finally, beneficial personality traits (9) is a cluster, which represents the traits that help a person to unfold the skills and abilities of health literacy, such as open-mindedness, willingness to change, self-confidence or curiosity. This analysis of clusters and regions provides a basis for developing a conceptual "qualitative" model of health literacy in the first step and for the construction and testing of a "quantitative" model of health literacy in the second.

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Table 3
Mean rating values of the 3-dimensional MDS cluster solution.

Cluster	*number of statements*	*mean value*	*SD*	*min*	*max*
(1) Self-regulation	14	3.745	0.523	2.47	4.18
(2) Self-perception	13	4.164	0.215	3.76	4.59
(3) Proactive approach to health	8	4.014	0.475	3.29	4.65
(4) Basic literacy and numeracy skills	7	3.707	0.990	2.00	4.65
(5) Information appraisal	20	3.717	0.450	2.76	4.41
(6) Information search	5	3.836	0.333	3.41	4.18
(7) Health care system knowledge and acting	13	3.435	0.532	2.47	4.24
(8) Communication and cooperation	12	3.333	0.555	2.47	4.06
(9) Beneficial personality traits	13	3.688	0.545	2.59	4.35
Total	105	3.721	0.558	2.00	4.65

4. Developing and testing a structural model of health literacy

4.1. Qualitative model of health literacy

Nutbeam's model of health literacy (Nutbeam, 2000) differentiates between basic skills and advanced skills and was used as a framework for constructing the qualitative model. Six clusters of the concept map were considered as advanced skills: self-perception (2), proactive approach to health (3), information search (5), information appraisal (6), health care system knowledge and acting (7), communication and cooperation (8). The cluster "basic literacy and numeracy skills (4)," was, as the naming implies, considered a basic skill. However, to better articulate the basic aspect of the model the content of this cluster was split into two components, namely "basic health related literacy skills" and "basic health related knowledge." The basic skills component of the model was expanded to include other prerequisites in addition to skills; cluster nine, personality traits was included here. Personality traits like openness are not skills that are modifiable; they are included in the *general* model at this stage, since these are usually considered as basic and beneficial prerequisites. This model (Fig. 2) formed the basis for the development of a measurement instrument.

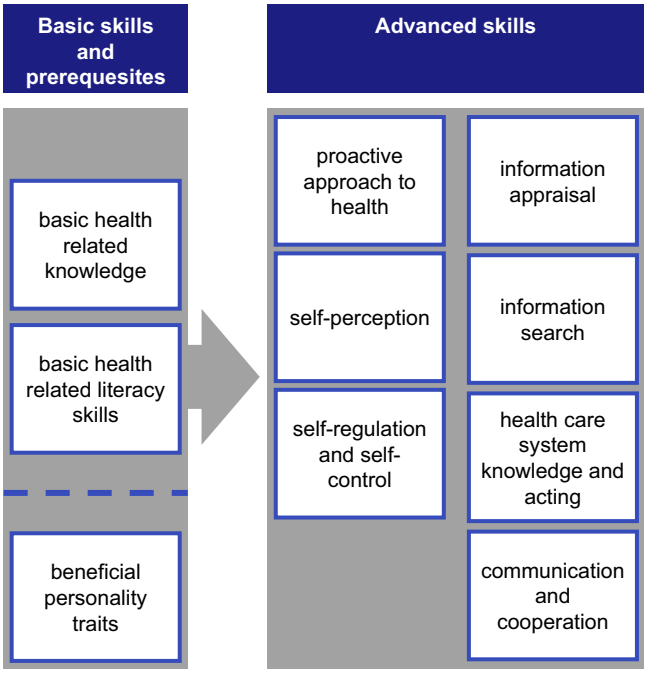

Fig. 2. Theoretical "qualitative" structural model of health literacy as a starting point for further analyses.

4.2. Measurement instrument

Since measures of basic health related skills and personality traits currently exist (e.g., Rapid Estimate of Adult Literacy in Medicine – REALM-R, Bass, Wilson, & Griffith, 2003; Test of Functional Health Literacy in Adults (TOFLHA), Parker, Baker, Williams & Nurss, 1995), we chose to focus the development of measures on the advanced skills in the qualitative model. A measurement instrument for the "advanced skills" was developed for each component of the model using statements from the concept map. Items were in a 5-point Likert-type format and ranged from strongly agree to strongly disagree. The questionnaire consisted of 70 items, approximately 10 items from each cluster included in the advanced skills of the qualitative model. The goal was to define congeneric measurement models for each of the seven concepts, meaning that different distinctive sets of the item pool are influenced by one and only one construct.

Four cross-sectional paper-and-pencil surveys were conducted involving in total 1173 participants from four high schools on the one hand (study 1 and 2) and adults recruited through a snowball sample on the other (study 3 and 4). For demographic details see Table 4. High school-students were invited via school administration. Data enrollment took place during class sessions in the area Cologne/Bonn in June 2009. Teachers were present during the sessions, participation was voluntary and students were encouraged to answer honestly and spontaneously. The participants spent approximately 20–30 min on the questionnaires.

To test whether the model would fit also in a broader adult population a snowball sampling was performed by university students of the Rheinische Friedrich-Wilhelms-Universität Bonn of two lectures in methodology in the summer term 2010. Each of them had to recruit 10 adults from his or her personal network. While analyzing data, study 2 was split in two samples (2a and 2b) in order to refrain from exploring and validating a model based on the same data set and thus installing tautology. Study 1 and 2a were exploratory (model-building and modifying), while study 2b, study 3 and study 4 were confirmatory. The analyses were performed using Mplus, version 6.11 (Muthén & Muthén, 2010).

4.3. Exploratory analyses

In structural equation modeling (SEM) exploratory factor analysis (EFA) serves to find optimal measurement models. The model specification search allows a plausible identification of the (assumed) latent variables (dimensions) behind a set of observed variables and leads to an estimation of factor loadings, which allows for an evaluation of the quality of the measurement model. We started with an initial seven-construct-baseline model as suggested by the qualitative model of the components depicted in Fig. 3 and tried to find, in a process of model modification, the optimal model. The initial set of 70 items (approximately 10 per scale) was reduced according to the critical values obtained by

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Table 4
Demographic characteristics of participants of SEM-Studies.

		N	Age				Gender		Education	
			Mean	Min	Max	SD	M	F	University-entrance diploma	other
Study 1	High school students	282	17.8	17	21	0.8	50.0%	50.0%	–	–
Study 2	High school students	327	18.1	16	21	0.6	35.5%	64.2%[a]	–	–
Study 3	Adults	227	36.0	20	65	12.7	43.2%	56.8%	82.8%	17.2%
Study 4	Adults	337	39.4	20	79	12.5	39.5%	60.5%	74.2%	25.8%

[a] One data point was missing.

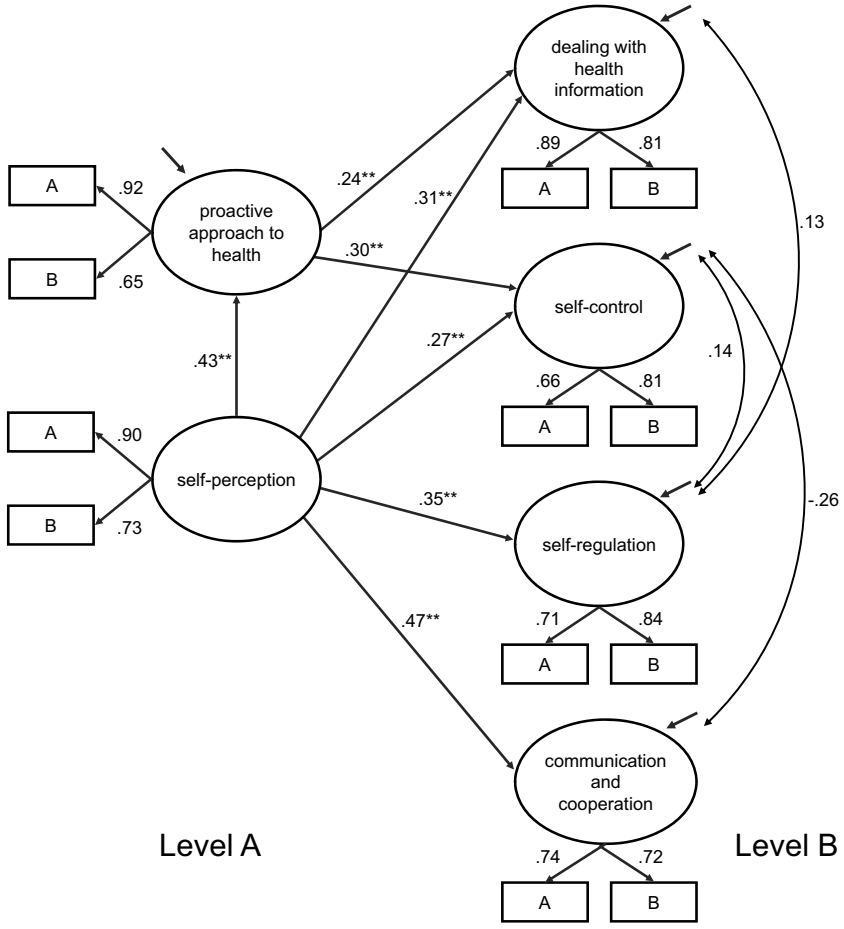

Fig. 3. Structural Equation Model of health literacy.
Note: n = 337; all parameters presented numerically are significant ($p < 0.01$). A and B in the rectangles symbolize so called item parcels, i.e. sets of 2 or 3 items indicating the corresponding constructs.

factor analysis (e.g., multiple loadings on several factors, i.e., not unidimensional; no substantial loadings, i.e., low reliability and validity) to 29 items representing six distinct scales measuring six concepts that were slightly modified from the qualitative model. Compared to the concept map (Fig. 1) and to the initial "qualitative" model of components (Fig. 2), health care system knowledge and acting within the health system (#7), information appraisal (#6), and information search (#5) collapsed to one scale, which was labeled "dealing with health information." On the other hand, "self-regulation" (#1) had to be differentiated explicitly in two dimensions "self-regulation" and "self-control", as already indicated in the discussion in connection to the qualitative model (Fig. 2). The remaining six scales with *examples of items* were as follows.

1. Self-perception: If I feel uncomfortable, I usually know exactly why,
2. Proactive approach to health: I take good care of my body,
3. Self-regulation: I can easily switch between phases of high concentration and phases of relaxation,
4. Self-control: When working on a task, I can prevent my thoughts from constantly wandering off,
5. Communication and cooperation: When I am not feeling well, I have no problem accepting someone's help,
6. Dealing with health information: Information about health is often unclear to me.

The theoretical dimensions of health literacy developed by concept mapping were largely reproduced, but they also required some empirically driven modifications. From a theoretical point of

view, the constructs in the structural part of the model are interrelated. These hypothesized interrelationships were the necessary precondition for exploring, in a next step, whether there are specific relations between the constructs (advanced skills) of which the inner structure is supposed to be a hierarchical one with two levels. On "level A" conditional skills are hypothesized, such as "self-perception" (1) and "proactive approach to health" (2), which could be interpreted as perceptive-motivational conditions, whereas on "level B" conditioned abilities are assumed, such as "self-regulation" (3), "self-control" (4), "communication and cooperation" (5), and "dealing with health information" (6), which could be interpreted as behavioral components of health literacy. Here the merging of the three information scales into one scale, on the one hand, and the partition of self-regulation into two scales, on the other hand, is taken into account. By analyzing models with these hierarchical types of structural relationships in an exploratory manner, this structural conjecture was corroborated.

4.4. Confirmatory analyses

The cross-validation of this model was conducted with three different samples (study 2b, study 3 and study 4) and was tested with confirmatory analyses through structural equation modeling. A key question to be answered by this analysis was, how pronounced is the degree of invariance of the confirmed model across different conditions and situations? Configural invariance occurs if and when the pattern of relations in the measurement model and the network of relations depicted by the paths at the structural level remain the same across samples (or over time). This form of invariance constitutes the basis for determining whether the construct of health literacy can be meaningfully applied across different samples. The assumption of configural invariance was confirmed by fitting the model to the data and, hence, getting finally an acceptable model fit according to the usual criteria.[2] The reliability of the questionnaire was acceptable. The factor loadings ranging from 0.66 to 0.92 and the internal consistency scores (Cronbach's α) of the health literacy scales were acceptable (self-perception = 0.78; proactive approach to health = 0.89; self-regulation = 0.75; self-control = 0.73; communication and cooperation = 0.70; dealing with health information = 0.85). The final model is presented in Fig. 3.

With the aim to prove generalization, the final model of health literacy was tested by confirmatory analysis again within the university context with several different samples (Kuhlmann et al., 2015). In a strict confirmatory approach, the configural invariance of the model was corroborated, that is, the model showed the same structure as the model in Fig. 3.

5. Conclusions & discussion

The aim of this study was to develop an empirically derived model of health literacy. To achieve this aim, concept methodology was used as a foundation for subsequent model building. Given the foundational aspect of concept mapping, it seemed useful to assess the similarity with other concept mapping efforts. Compared to the 69 studies analyzed in a pooled study analysis on the quality and rigor of the concept mapping methodology by Rosas and Kane (2012), our study may be evaluated as typical and extraordinary at the same time. As with the majority (59.4%) of the studies Rosas and Kane (2012) analyzed, the topic also belongs to the public health sector category. The purpose, which is purely research and theory building, however, belongs to a minority (7.2%). The number of participants for our brainstorming was lower, while the number of participants completing the sorting task was equal to the studies summarized (Rosas & Kane, 2012). The number of groups in sorting in our study and the number of clusters were quite close to Rosas and Kane (2012) findings; an average of 12.07 sorted groups of items in our study versus 10.93 and nine clusters in our study versus an average of 8.93.

The model presented here adds to the picture of health literacy derived empirically by Jordan et al. (2013) which also relied on concept mapping. In that study, Jordan developed the construct of health literacy from a patient perspective. While the patient perspective is important, Jordan et al. (2013) stated, "in addressing health literacy the focus should not lie solely with the patient" (p. 234). Our study addresses this point by expanding the perspective on health literacy with input from experts in healthcare and demonstrates where the different perspectives (patient vs. provider) share similar ideas about health literacy. In the Jordan model 'Patient attitudes towards their health' as well as 'Being proactive' are addressed in the 'Proactive approach to health' in our model; 'Communication with health professionals' and 'Using health information' in the Jordan model is consistent with our 'Communication and cooperation' component, while Jordan's 'Understanding health information' as well as 'accessing GP healthcare services' refers to our 'Dealing with health information'. In another respect, our model provides a different view of health literacy. Literacy and numeracy skills are considered most important in the health literacy literature (American Medical Association 1999; Parker et al., 1995) but in the concept mapping phase of our research, the statements in this domain received the lowest mean ratings. Several conclusions seem warranted. The overlap of our map with the Jordan map points to the utility and validity of this methodological approach. In fact, the questionnaire developed on the basis of this concept map might be a helpful tool for the validation of the HeLMS (Jordan et al., 2013) and vice versa. Finally, the fact that our empirical results are not completely consistent with theoretical opinions about health literacy reflects, in our opinion, the open and non-paradigmatic approach of concept mapping.

On the basis of concept mapping, a model of health literacy was developed which (a) provides insight into the structure and components, (b) overcomes individual representations and interpretations, (c) is not determined by theoretical and purely "academic" assumptions, and (d) is transparent and comprehensible in the process of formation. The structural model describes a clear hierarchical concept that is consistent with the theory of self-determination (Ryan & Deci, 2000) and it can be hypothesized that the promotion of these health-related skills could lead to an improvement in health literacy and an improvement in health. Future research should examine whether these health literacy models and corresponding questionnaires might be helpful in evaluating health literacy related interventions.

While the evidence for this model is strong, there are limitations. Concept mapping is not a strictly empirical method, decisions needed to be made by the researchers. To mitigate the potential for bias, decisions were made by consensus and we recognize that consensus may not avoid bias and agreement might, nonetheless be delusory. Nevertheless, the hypothesized underlying constructs were identified and confirmed by EFA and CFA. The structural model based on the concept map, served as a starting point for developing a standardized measurement of health literacy. In this process, the results of the sorting, rating and clustering procedure provided helpful information to structure the domain of health literacy, the subdomains (i.e., the concepts), and to develop a questionnaire. The questionnaire proved to be reliable

[2] χ 2 = 79.195; df = 41; p = 0.000; CFI = 0.969; TLI = 0.949; RMSEA = 0.053 und SRMR = 0.041.

Please cite this article in press as: R. Soellner, et al., Concept mapping as an approach for expert-guided model building: The example of health literacy, Evaluation and Program Planning (2016), http://dx.doi.org/10.1016/j.evalprogplan.2016.10.007

and valid, and the structural model was replicated and cross-validated via structural equation modeling with different samples.

This points to the validity of the map on the one hand and, on the other hand, it points to the usefulness of the method of concept mapping as a method to explore a vaguely defined domain.

Acknowledgements

The research project was funded by the Deutsche Forschungsgemeinschaft (DFG) (DFG-Gz.: SO 899/1-1), and was part of a Priority Program on Competence Models for Assessing Individual Learning Outcomes and Evaluating Educational Processes.

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