The use of concept mapping to enlighten the knowledge networks of diabetic children: a pilot study

C Pinosa¹, C Marchand¹, N Tubiana-Rufi², R Gagnayre¹, MG Albano³, JF D’Ivernois¹

SUMMARY

Objective: The value of concept mapping in enlightening nature and organization of knowledge was shown with adult diabetic or obese patients. Our objectives were to ascertain the relevance and feasibility of concept mapping in diabetic children during an educational program.

Method: This qualitative research was performed in 5 children from 8 to 13 years. Concept maps were drawn at the beginning (Phase 1) and at the end (Phase 2) of an educational program. During the interview each child was invited to express himself starting from the central concept: “diabetes”, and to express his/her knowledge, representations, and life experience.

Results: The ten maps analysis shows: an increase of knowledge between phase 1 and phase 2 (+34%), towards a deepening of initial knowledge and an addition of new knowledge (43% and 41% of the added knowledge); a decrease of inaccurate knowledge in phase 2; an enrichment of the knowledge networks (+16 cross links); an increase of knowledge related to the ways to behave knowledge (+42%).

Conclusion: This preliminary report demonstrated that concept maps were feasible, useful and relevant in therapeutic education of children. This method allowed us to show how every child connected his knowledge and how it was modified by an educational intervention. Concept maps therefore contributed to individual educational diagnosis and assessment of new knowledge integration.

Key-words: Concept mapping · Knowledge organization · Diabetic children · Therapeutic education.

RESUMÉ

Utilisation des cartes conceptuelles pour révéler le réseau de connaissances des enfants diabétiques : une étude pilote chez les enfants

Contexte : Les cartes conceptuelles, utilisées auprès de patients adultes atteints de maladie chronique, ont montré leur intérêt pour identifier la nature et l’organisation des connaissances de ces patients. Les objectifs de cette étude portent sur la faisabilité et les intérêts d’utiliser les cartes conceptuelles auprès d’enfants diabétiques au cours d’un programme d’éducation.

Méthodes : Cette recherche qualitative concerne 5 enfants diabétiques de 8 à 13 ans. Des cartes conceptuelles ont été élaborées par le chercheur au cours d’un entretien individuel avec chaque enfant, avant (Phase 1) et à la fin (phase 2) d’un programme d’éducation.

Résultats : L’analyse de 10 cartes conceptuelles montre une augmentation du nombre de connaissances (+34 %) entre P1 et P2, en termes d’approfondissement ou d’acquisition de nouvelles connaissances (43 % et 41 % des connaissances ajoutées en P2), une diminution des connaissances erronées à l’issue de l’éducation. Elle montre une amélioration de la structuration des connaissances par une augmentation des liens entre les domaines de connaissances (+16 liens), et une augmentation des connaissances d’action entre P1 et P2 (+42 %).

Conclusion : Cette étude permet d’affirmer que la technique des cartes conceptuelles utilisée auprès d’enfants de 8 à 13 ans, produit de nombreuses informations sur les connaissances antérieures des enfants et leur évolution à la suite d’un programme d’éducation. Il est possible d’envisager une utilisation plus étendue de la technique des cartes conceptuelles aux différents temps de la démarche éducative : pour la réalisation d’un diagnostic et la définition d’objectifs d’éducation personnalisés par exemple.

Mots-clés : Cartes conceptuelles · Organisation de connaissances · Enfants · Diabète · Éducation thérapeutique.

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therapeutic education helps patients with a chronic disease to develop a self-care competence. One fundamental step of this process consists in taking into account their preliminary knowledge about their disease and their treatment. Indeed, according to the theory of cognitive psychology, the nature and the organization of this preliminary knowledge said “previous knowledge” influence the learning process [1].

To investigate on this previous knowledge in particular in diabetic children, the classic techniques are tests and questionnaires [2, 3]. Most of these questionnaires testify the mastery of factual knowledge of the children. Other types of questions allow to investigate on their problem solving capacities [4].

Another way to obtain information on previous knowledge organization, is the technique of concept mapping [5, 6]. Indeed, it allows to represent diagrammatically the knowledge of a person, from a subject or from a given concept, as well as the way these concepts are connected to each other. This technique proposed by Novak et Gowin [7] was used initially to make students’ learning more meaningful, in opposition to rote learning, helping the students to link the new and the previous knowledge. Its application to education deals with several scientific disciplines [8-12]. Some authors use concept mapping to assess students’ learning [13, 14].

The value of this technique for therapeutic education of diabetic adults and obese subjects has been recently demonstrated [5, 6, 15]. From these first studies a matrix for analysis of concept maps has been proposed allowing to evaluate the nature of patients’ knowledge (knowledge categories, nature of the links connecting the concepts, validity of the knowledge), as well as the way this knowledge is organized (domains of knowledge, existence or absence of links among the various domains of knowledge). This matrix was partially inspired from the analysis criteria proposed by the authors of concept mapping technique [7].

When five year old children learn to write, the use of concept mapping showed value in school education. Even the youngest children (from age 4, in kindergarten) are able to draw concept maps which encourages the development of their thought, their capacity to build and memorize knowledge [16]. Children like to show their progress in the organization of their thought. From their part, the teachers notice that children’s understanding is improved when they are brought to build concept maps [12, 16].

We were interested in the use of concept mapping with diabetic children during a therapeutic educational program. The aim of this study is to ascertain the relevance and feasibility of concept mapping with these children. Our aim was not to estimate the impact of the therapeutic educational program on children’s knowledge, but to identify the possible advantages of concept mapping in showing and describing the modifications of children’s knowledge attending the program.

This led us to the following questions:
• Is this technique relevant to the diabetic child’s therapeutic education?
• Does it allow to show the organization and the nature of the children’s’ knowledge?
• Is it particularly interesting for the children (pleasure to visualize their knowledge scaffolding, etc.)?

Method

Since the purpose of this study is to describe in depth the modifications of children’s knowledge, it has a qualitative character and concerns therefore a limited sample (5 children) [17].

Population

This study deals with five diabetic children hospitalized in the Department of Endocrinology and Diabetology at the Robert Debré Hospital in Paris. We selected at random, since it seemed possible to use concept mapping from the age of five. All the 5 children admitted in the Department for a 5 day program, including care and education, participated in this study. They were 5 years old and older. We took a girl and four boys (Tab 1), aged 8 to 13 with different sociocultural backgrounds. Their diabetes was diagnosed between 1 month and 11 years earlier, having a HbA1c from 7 to 15.5%. They were hospitalized for a discovery of the diabetes or its imbalance. Three of the five children had benefited from educational program on diabetes during previous hospitalization (Subjects 2, 4, 5). The other two had never attended a therapeutic educational program.

Table I
Presentation of the children, subjects of the study.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Age, school level</th>
<th>onset of DID</th>
<th>Reason of hospitalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject 1</td>
<td>Girl, age 12</td>
<td>4 years HbA1c = 11%</td>
<td>IDDM Unbalanced Change of insulin therapy</td>
</tr>
<tr>
<td>Subject 2</td>
<td>Boy, age 10 and half</td>
<td>2 years 1/2 HbA1c = 7%</td>
<td>Frequent hypoglycemia Change of insulin therapy</td>
</tr>
<tr>
<td>Subject 3</td>
<td>Boy, age 8</td>
<td>1 month HbA1c = 9.2%</td>
<td>Bare, implementation of the treatment</td>
</tr>
<tr>
<td>Subject 4</td>
<td>Boy, age 13</td>
<td>11 years HbA1c = 15.5%</td>
<td>IDDM Unbalanced</td>
</tr>
<tr>
<td>Subject 5</td>
<td>Boy, age 12</td>
<td>4 month HbA1c = 10.2%</td>
<td>Frequent hypoglycemia of dietary origin overweight</td>
</tr>
</tbody>
</table>
Concept mapping drawing procedure

We used the methodology of building the maps described in previous studies with diabetic and obese adults [5, 6, 15]. This method, inspired by Novak and Gowin [7], consists in building a concept map from a central concept during an interview. In our study, the central concept was: “diabetes”. The choice of this concept answers to two principles: it is, a priori, known by all the children included in this study, and it is wide enough to generate several other concepts concerning the disease [18]. The interviewer has used techniques to help the explicitation [19] inciting the children to express their knowledge. The interviewer registered gradually the words used by the child, as well as the links they created among them. The verbatim was also recorded.

The protocol consisted of the drawing of concept maps at the beginning (Phase 1) and at the end of the educational program (Phase 2). At phase 2, we read with the children the maps drawn in phase 1, and asked them to validate, complete or modify the knowledge which they had expressed at phase 1.

Concept maps analysis

Analysis preliminary procedure

The listening of the recorded tapes allowed checking the exactness of the information collected during the interview. Maps were then redrawn with the help of the softwares “Power Point” and “Inspiration” to make them clearer, more legible and attractive for the children.

In order to facilitate the data analysis, concept maps were divided into knowledge units (2 concepts united by a link) [20]. These were transferred in tables according to predetermined organizing concepts named superordinate concepts (including the central concept) [5]: diabetes, hypoglycemia, hyperglycemia, treatment, food, sport, self-control, and complications. Each of these concepts, or synonyms, determines a relatively wide domain of knowledge, susceptible to generate numerous links and more and more precise concepts. Indeed, according to Ausubel’s theory [1], any new concept can be connected to a wider one, this latter one being able to determine a domain of knowledge. For example, in both the following knowledge units: “The hypoglycemia provokes an illness” and “an illness with sweats”: hierarchically the widest concept is that of hypoglycemia (superordinate concept) and the concepts “illness” and “sweats” represent concepts of subordination (because they are subordinated to a wider concept: hypoglycemia).

Indicators of the knowledge organization

The organization of knowledge was analyzed during the two phases of the study by:
– comparing the number of links starting from superordinate concepts in the maps of the patients, in order to determine the most structured concepts. Indeed, the more the links starting from a concept are numerous, the more they prove their structuring quality and ability to organize the knowledge[5];
– appreciating the existing number of cross links between the various superordinate concepts testifying an organization in network of the knowledge [1].

Indicators of the knowledge nature

The knowledge nature was analyzed in two phases of this study using the following four indicators:
– The nature of the links connecting two concepts between them allowed to classify the knowledge in 4 categories: the knowledge dealing with disease in general, the knowledge describing the links of causes and effects, the knowledge about “preventive or curative ways to behave”, and finally, the knowledge relating to how the children express the way they live with the disease.
– Moreover, we tried to consider whether these knowledge were purely declarative (i.e. factual, general knowledge not related to a given context), decontextualised [20], expressing laws, rules, norms (ex: the normal glycaemia is situated between 0,8-1,2 g/l), or taken by the patients, put in link with their context and much more detailed. For example, the patient justifies a reasoning “I re-sweetened only with 2 sugar pieces… because…”. We named this last category: constructed knowledge.
– The exactness of the knowledge expressed in concept maps was assessed by an expert in diabetology. We differentiated the exact knowledge from the erroneous one and from those estimated more or less exact. This last category includes the knowledge considered indistinct by the expert or by the child himself.
– Finally, the modifications brought by the children during phase 2, were also analyzed. Knowledge was repeated, added (new knowledge), canceled (crossed from the map), or clarified.

Children’s interest for the technique

We tried to appreciate the children’s interest for concept mapping as an educational resource. We try to answer to the following questions:
Do the children agree to draw the map in phase 1 and 2?
Do they agree to keep the map drawn in phase 1 and 2 when it was proposed to them?
Do they keep the map drawn in phase 1? Do they bring it back during phase 2?
Do they spontaneously bring modifications (additions, erasures) on the map between phase 1 and 2?

Results

Concept maps analysis

Ten concept maps were drawn. Two parts of concept maps drawn by subject number 1 are shown on figures 1 and 2. The following results are related to the analysis of the 10 maps.
Analysis of knowledge organization

The three most developed domains of knowledge were (Tab II): the disease (71 links), the treatment (47 links), and the hypoglycemia (43 links), while the fields of knowledge on the complications and the physical activity were less developed (18 and 14 links).

The detailed analysis of the results showed however that every child can develop a particular field of knowledge according to his concerns (e.g.: the subject 1 expressed 8 supplementary links concerning hyperglycemia in phase 2) (Fig 2).

The concept which was mostly connected with the other superordinate concepts was that of disease (30 links), fol-
allowed by the concepts of hypoglycemia (14 links), treatment (13 links), food, hyperglycemia, sport, self-monitoring and complications.

All the children expressed new cross links between superordinate concepts at the end of the educational program (+16 links).

Analysis of the knowledge nature

In phase 1, the links most often expressed were (Tab III): general concepts (37%), “ways to behave” (32%) and links of causes and effects (21%). In phase 2, the children completed their maps (+34% compared to P1). They did it more gladly with links of “ways to behave” (40% of the expressed links in P2).

The majority of the expressed knowledge is said “built” in phase 1 (P1) as well as in phase 2 (P2) (52%, +52%). A more detailed analysis shows however that three children out of five (subjects 2, 3, 5) expressed more declarative knowledge than built knowledge in phase 1.

In phase 1, 84% of the knowledge found in concept maps were considered exact by the expert, 8% were erroneous, and 8% seemed indistinct. This tendency remained unchanged in regards to the knowledge collected in phase 2 (80% true, 9% false, 11% vague). The majority of the knowledge identified as “indistinct” between phases 1 and 2, that is 13 out of 24, were said so by the children themselves.

In phase 2, the children clarified more gladly knowledge expressed in P1 (43% of the knowledge expressed in P2). They have also: enriched their map by new knowledge (41%), canceled some knowledge (13% of the modification

<table>
<thead>
<tr>
<th>Superordinate concepts</th>
<th>Number of links leaving each superordination concept N = 5 children</th>
<th>Number of cross links N = 5 children</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease</td>
<td>66</td>
<td>+5</td>
</tr>
<tr>
<td>Treatment</td>
<td>33</td>
<td>+14</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>33</td>
<td>+10</td>
</tr>
<tr>
<td>Diet</td>
<td>29</td>
<td>+12</td>
</tr>
<tr>
<td>Hyperglycemia</td>
<td>25</td>
<td>+14</td>
</tr>
<tr>
<td>Self control</td>
<td>24</td>
<td>+8</td>
</tr>
<tr>
<td>Physical activity</td>
<td>10</td>
<td>+4</td>
</tr>
<tr>
<td>Complication</td>
<td>8</td>
<td>+10</td>
</tr>
<tr>
<td>Total</td>
<td>228</td>
<td>+77</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Type of concept links</th>
<th>Number of knowledge % Nber and % of knowledge added</th>
<th>% Gain compared to P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Links of general expression</td>
<td>84 37% 22 (29%) +26%</td>
<td></td>
</tr>
<tr>
<td>Link of personal expression</td>
<td>22 10% 8 (10%) +36%</td>
<td></td>
</tr>
<tr>
<td>Cause and effect links</td>
<td>48 21% 16 (21%) +33%</td>
<td></td>
</tr>
<tr>
<td>Ways to behave links</td>
<td>74 32% 31 (40%) +42%</td>
<td></td>
</tr>
<tr>
<td>Total number of links</td>
<td>228 100% 77 (100%) +34%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Knowledge categories</th>
<th>Number of knowledge % Nber and % of knowledge added</th>
<th>% Gain compared to P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declarative knowledge</td>
<td>110 48% 37 (48%) +34%</td>
<td></td>
</tr>
<tr>
<td>Built knowledge</td>
<td>118 52% 40 (52%) +34%</td>
<td></td>
</tr>
<tr>
<td>Total knowledge</td>
<td>228 100% 77 (100%) +34%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Validity of knowledge</th>
<th>Number of knowledge % Nber and % of links added</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate knowledge</td>
<td>173 84% 55 (80%)</td>
<td></td>
</tr>
<tr>
<td>Inaccurate knowledge</td>
<td>17 8% 6 (9%)</td>
<td></td>
</tr>
<tr>
<td>Indistinct knowledge</td>
<td>16 8% 8 (11%)</td>
<td></td>
</tr>
<tr>
<td>Total*</td>
<td>206 100% 69 (100%)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modification</th>
<th>Nber and % of knowledge concerned</th>
<th>% of Knowledge modified compared to P1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canceled</td>
<td>12 (13%) 5%</td>
<td></td>
</tr>
<tr>
<td>Repeated</td>
<td>3 (3%) 1%</td>
<td></td>
</tr>
<tr>
<td>Precised</td>
<td>38 (43%) 17%</td>
<td></td>
</tr>
<tr>
<td>News</td>
<td>36 (41%) 16%</td>
<td></td>
</tr>
<tr>
<td>Total**</td>
<td>89 (100%) 39%</td>
<td></td>
</tr>
</tbody>
</table>

*This total excludes personal expressions whose validity can not be valued. **This total corresponds to the number of concepts studied in P2 (77) to which the crossed knowledge is added (12).
observed in P2), or still repeated the knowledge expressed in P1 (3%). We observed that all the erroneous knowledge in P1 was corrected in a proper way in phase 2.

**Children interest towards concept maps**

All the children agreed to draw a concept map in phase 1 as in phase 2. They agreed to receive a copy that they all added to the various didactic documents received during the program. However, no one spontaneously brought modifications to his/her map, neither at the time of the drawing of the maps, nor between phases 1 and 2.

**Discussion**

**Is concept mapping a feasible and useful technique with diabetic children?**

No methodological difficulty was met to realize concept mapping at the beginning and at the end of the educational program. However, the authors are aware that the small number of patients included in the study reduce the degree of generalization possible and that the distribution of ages in the group is not homogeneous (a 13 year old subject may be considered more an adolescent than a child). From their part, the children showed no hesitation toward the technique used. Concept mapping seems useful with children aged 8 to 13, if the children agree to express themselves and if they are appropriately guided in expressing their knowledge. Other studies confirm that it is possible to use concept mapping with 4 or 5 year old children [16]. In this case, the health care provider should adapt his language and his questioning technique according to the stage of development of the child and his ability of abstraction [21].

**What do concept maps show on the nature and organization of knowledge?**

Regarding the knowledge organization, results similar to those identified in adults are found in children [5]. Concept maps reveal an improvement of the structuring of the knowledge in networks, reflecting the characteristic more and more elaborated of the knowledge [1]. Moreover, the identification of the more organizing concepts can inform us about the evolution of the children concerns at the beginning and at the end of the educational program. So, the most developed domains of knowledge (dealing with a superordinate concept) could be indicators of the concerns that children can develop at a given moment. For example, in subject 5 (12-year-old), hospitalized for imbalanced diabetes from a dietary cause, the structuring concept was modified between phases 1 and 2 (respectively hypoglycemia and food). The concept map shows well at this level reorganization by the child of his knowledge dealing with different superordinate concepts. This visualization can help the health care provider to ask the child about the reasons of this change. For example, for this child, could this reorganization be the consequence of an awareness during the program of the influence of food on his health?

Concept maps inform us also about the nature of children knowledge. We have observed that at the end of the educational program, the children principally expressed knowledge related to ways to behave (actions). This supports the educational aim of the program, which allows the child to manage his disease and his treatment, and to ascertain number of actions. Moreover, concept mapping shows at the end of the program, the results of the learning in terms of modification and acquisition of knowledge (additional or more precise knowledge and correction of the erroneous knowledge).

In our study, concept maps show that on average the majority of the expressed knowledge (52% in the two phases of this study) is of constructed nature. It is the case for 2 children in phase 1 (subjects 1 and 4) and for 3 children in phase 2 (subjects 1, 4, 5). The concentration of the child on himself at a certain stage of his development could explain this difference. According to Piaget theory [21], between the age of 2 and 7, the child represents himself the world from his own point of view and develops reasoning according to what he perceives. During the next step of development, this concentration decreases gradually allowing the child to consider other points of view, to elaborate logico-mathematical reasoning and so to express more declarative knowledge.

Finally, the use of concept mapping with children puts in evidence the following aspects:

- Concept mapping underlines how difficult it is to modify previous knowledge [5]. For example, the child 1 believed in P1 and P2 that it is possible to treat his diabetes with pills.
- A concept map allows to identify one’s representation of an event. For example, child 3 representation of his understanding of the onset of his disease: “one brings the child to the hospital, the nurses make an injection and then he is cured and after that he becomes diabetic”.
- The freedom of expression given to the child during the drawing of a concept map encourages him to express specific signs of hypoglycemia or hyperglycemia. For example, subject 2 said: “I have a burning sensation”, subject 5 “I feel disconnected”. Consequently, this technique may help the child to begin to put into words his own symptoms.
- Finally, concept mapping allows the children to express their emotions and feelings towards their disease (10% of the links). The expression of the children’s feelings and their own analysis at distance seem particularly interesting, considering the influence that these feelings may have on their learning [22].
Value of concept mapping for the children

It seems that the children were able to find an interest in this method. Indeed, they all appreciated to receive their map, thanks to which they objectivized their knowledge, made it visible, and became aware of their learning. Furthermore, the erasing of the errors and replacing it by new knowledge contributes, according to some authors, to help the child to integrate his knowledge through an active construction of it [16, 23].

During the drawing of the maps, the children identified themselves the indistinct knowledge. Interrogating the children explicitly embarrassed them and they may interpret this feeling as a doubt on the validity of this kind of knowledge. This uncertainty may stimulate the desire to learn [24].

Practical implications for therapeutic education

The technique of concept mapping seems to represent an important educational potentiality. Indeed, it presents several advantages at the various phases of an educational program: educational diagnosis, definition of learning objectives, running of the program, evaluation.

Concept maps put into evidence the concerns, the questioning of the children through the expression of their previous knowledge. Maps inform all care providers involved in the education on the language used by the children in talking about their disease, on their way of reasoning and on their problem solving competence. During the educational diagnosis, at the beginning of hospitalization or during consultations, they allow the educator to determine the “proximal zone of development” of the child according to Vygotsky theory [12, 25]. This “proximal zone” represents the potentiality of a child to achieve more complex tasks if he is helped by an adult. By reading the map, the educator can determine this zone and translate it into educational objectives tailored to each child [26].

Concept mapping can be also used during education to stimulate the child to clarify and to complete his knowledge and to argue on it. It becomes possible to make the child aware of his reasoning errors, identified on the map by the visualization and the verbalization, in order to help him to correct them. Finally, at the conclusion of every educational sequence, time can be given to let every child add the acquired knowledge to his map.

At the end of education, concept mapping can be used to assess the integration of new knowledge and reasoning, with the purpose of defining new educational objectives. Furthermore, concept mapping can inform the health care providers about the quality of teaching. Its capacity to help the patient in creating new links and modifying previous knowledge can also be appreciated.

Conclusion

Experiences in therapeutic education show that interview and verbal exchanges with ill children can be difficult. In this study we showed that the technique of concept mapping facilitates the educational relationship with diabetic children. It allows the child to demonstrate his knowledge and the health care provider to become aware of what he knows. It reveals the transformation of knowledge, and helps the care provider to ask meanings that the child gives to his knowledge. Through a series of concept maps one can follow the evolution of knowledge and the analysis of concept maps can also contribute to define more personalized educational objectives. Furthermore, concept mapping put into evidence the erroneous conceptions and the absence of important cross links among various domains of knowledge. So, one of the major value of concept mapping is the identification of the child’s misunderstanding leading to non-compliance or incidents due to an inappropriate application of therapy. However, health care providers should be trained to apply and interpret concept maps adequately.

Notes:

A communication about this study has been done on Colloque “Santé-Education”, DELF, February 2001 (Abstract p7).

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References


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