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Mind Mapping as a Tool in Mathematics Education

Mind mapping is a special technique for taking notes. Ideas and concepts connected with a topic are displayed as a graphical pattern—in many instances, even as in an artistic image. The mind-mapping technique takes into account the special way that the human brain works and thus facilitates the organization of information and increases productivity and memory retention.

This article presents the technique of mind mapping, points out its utility as a pedagogical tool for mathematics education, and discusses possible applications of mind mapping in mathematics education, as well as the advantages and limits of mind mapping. Mind mapping is an effective tool to improve achievement and offers a welcome and delightful change in mathematics education.

INTRODUCTION

Mind mapping was invented by Tony Buzan, a mathematician, psychologist, and brain researcher. It was first developed as a method for taking notes as briefly as possible and in a manner that is interesting to the eye. It is usable in many different ways in addition to simple note taking.

Mind mapping connects imagination with structure and pictures with logic

The method of mind mapping basically takes into account that the two halves of the human brain perform different tasks. The left side is mainly responsible for logic, words, arithmetic, linearity, sequences, analysis, and lists; whereas the right side of the brain mainly performs tasks that relate to multidimensionality, imagination, emotion, color, rhythm, shapes, geometry, and synthesis.

Mind mapping uses both sides of the brain (Buzan 1976), lets them work together, and thus increases productivity and memory retention. It represents logical structures by using an artistic spatial image that the individual creates. Thus, mind mapping connects imagination with structure and pictures with logic (Svantesson 1992, p. 44; Beyer 1996).

RULES FOR MAKING MIND MAPS

Mind maps are produced by using the following rules (see, e.g., Beyer [1993]; T. Buzan and B. Buzan [1993]; Hemmerich, Lim, and Neel [1994]; Hugl [1995, p. 182]; Svantesson [1992, pp. 55–56]:

1. Use a large unlined sheet of paper in landscape format.
2. Draw or write the topic of the mind map in the center of the paper. The topic of the mind map should be displayed in an eye-catching way, preferably with a colored drawing. If a picture does not seem appropriate, the topic should be indicated with a well-chosen key word, as shown in **figure 1a.**
3. From the topic, draw a main branch for each of the main ideas that are linked to the topic. Write key words that denote the main ideas directly on the lines, using printed letters. The order of the branches is not important. If the ideas must be written in a specific order to facilitate understanding, number the branches or order them clockwise. If possible, write only one word, preferably a noun, per line. Since many of the words in texts are unnecessary, using a few meaningful key words is sufficient to allow for one to remember the entire context. See **figure 1b.**
4. Starting from the main branches, you may draw further lines (subbranches) for secondary ideas (subtopics), and so on. The order goes from the abstract to the concrete, from the general to the specific. See **figure 1c.**
5. Use colors when drawing a mind map.
6. To your mind map, add images, sketches, and symbols, such as little arrows, geometric figures, exclamation marks, or question marks, as well as self-defined symbols. See **figure 1d.**

MATHEMATICAL MIND MAPPING

Ever since mind maps were invented, they have been used in many fields. Although they have often been used in education, they are rarely used

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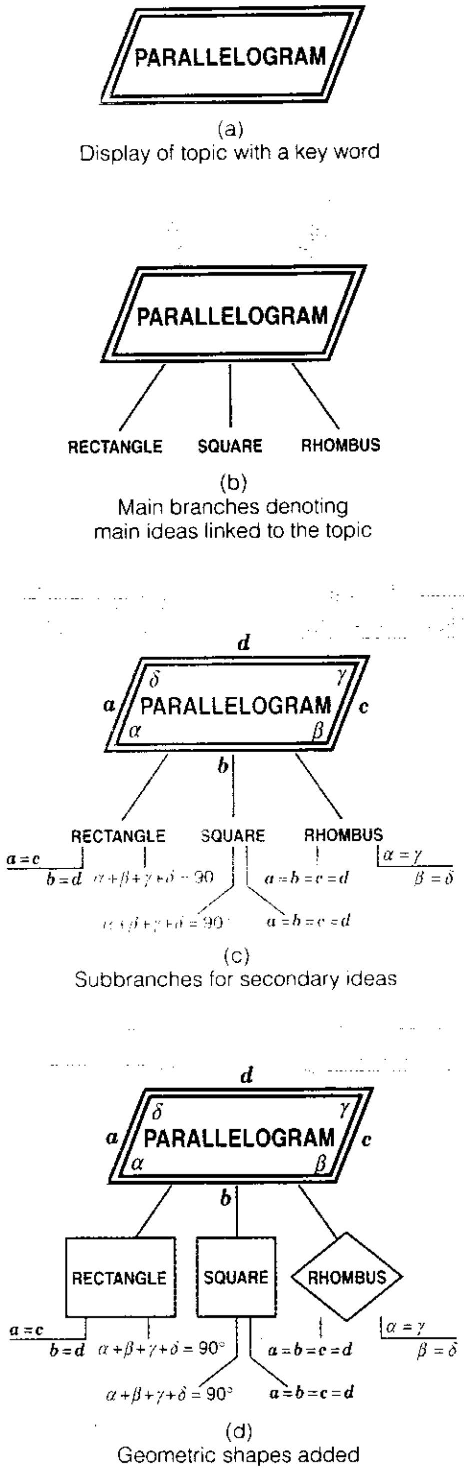

Fig. 1
A mind map on the topic of parallelograms

in mathematics. Since both the structure of mind maps and the technique of mind mapping emphasize the relevance of mathematical issues as topics for mind maps, this result is very surprising (Brinkmann 2000, 2001b, 2002).

As shown in **figure 2,** the structure of a mind map resembles that of a tree, as viewed from the top. From the trunk in the middle, representing the topic of the mind map, the lines for the ideas linked with the topic branch off like tree branches. Thus, a mind map is structured similarly to mathematics: "Mathematics is often depicted as a mighty tree with its roots, trunk, branches, and twigs labelled according to certain subdisciplines. It is a tree that grows in time" (Davis and Hersh 1981, p. 18). Mind maps enable people to visualize relationships between mathematical objects in a structured way that corresponds to the structure in mathematics (Brinkmann 2000, 2001a).

Mind mapping assists mathematical thinking

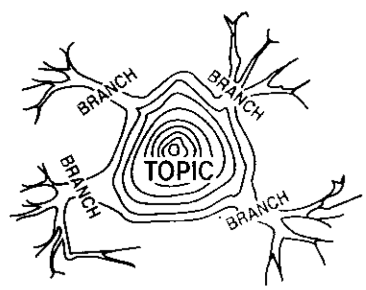

Fig. 2
Structure of a mind map

The special technique of mind mapping, which uses both sides of the brain and has them work together, assists mathematical thinking, which takes place in both sides of the brain. The left hemisphere is better suited for analytic deduction and arithmetic, whereas the right hemisphere is suited for spatial tasks, for example, geometry.

However, no strict brain mapping exists with respect to the single functions of the brain areas; several parts of the brain are involved for each cognitive function (Engel, König, and Singer 1993, p. 42; Poeck 1997, p. 34). Moreover, a number of investigations show that the tasks of the different parts of the brain are influenced by hormones, thereby indicating some gender differences (Rubner 1996). Hemispheric specialization may be described as a continuum of functions between the hemispheres, the differences being quantitative rather than qualitative (Pehkonen 1991, 1997).

However, differences exist with respect to the mathematical thinking going on in each of the two hemispheres. The constant emphasis in mathematical education on rules and algorithms that are usually sequential may prevent the development of creativity and spatial ability (Pehkonen 1997). Thus, "the balance between logic and creativity is very important. If one places too much emphasis on logical deduction, creativity will be reduced. What one wins in logic will be lost in creativity and vice versa" (Pehkonen 1997; see also Kirckhoff [1992, p. 2]). Accordingly, Davis and Hersh (1981, p. 316) "suggest that in mathematics it would be better for the contributions of the two halves of the brain to cooperate, complement, and enhance each other, rather than for them to conflict and interfere."

APPLICATIONS OF MIND MAPPING

In mathematics education, mind mapping may be used with several different aims. Some of the most important are as follows.

Mind maps make a learner's knowledge structure visible

Mind maps help organize information.

Mind mapping supports the natural thinking process, which goes on randomly and in a nonlinear way. Since mind maps have an open structure, the creator can just let his or her thoughts flow. With almost no mental effort, every idea produced can be integrated in the mind map by relating it to already recorded ideas.

The hierarchical structure of a mind map conforms to the general assumption that the cognitive representation of knowledge is hierarchically structured (Tergan 1986). Mathematical knowledge can thus be organized in a mind map according to the mental representation of this knowledge. A clear and concise overview of the connectedness of mathematical objects around a topic is possible. Moreover, the use of colors and pictures supports these connections.

Mind maps can be used as a memory aid.

Each mind map has a unique appearance and a strong visual appeal. Thus, information may be memorized and recalled faster, the learning process speeds up, and information becomes long living.

Mind maps can assist with repetition and summary.

At the end of a teaching unit, the subject matter of the treated topic can be repeated and structured by composing a mind map; this mind map then serves as a good memorizable summary.

A mind map may also grow as the common task of an entire class. The teacher might write the topic in the middle of the chalkboard and ask the students what main ideas they connect with it. For each idea, the teacher draws a main branch of the mind map. Later, the students are asked to tell all other ideas that they link to these main ones. Because of the open structure of a mind map, each single contribution can be integrated. Each student should then redraw the complete mind map in his or her personal style.

Mind maps help to meaningfully connect new information with existing knowledge.

New information can be integrated into an existing mind map and related to previously learned concepts. The teacher, who has the overview of already created mind maps and understands how new concepts fit with old topics, must initiate such an activity.

Mind maps may introduce new concepts.

Entrekin reports that she used mind maps to introduce new concepts in mathematics classes. The new concept

> is written on the chalkboard or transparency. As the concept evolves in later lessons, the teacher may add additional components and form an extended mind map. This visual representation serves to help students relate unknown concepts to known concepts. (Entrekin 1992, p. 444).

Mind maps let cognitive structures of students become visible.

Mind maps drawn by students provide information about the students' knowledge. In broad outline, mind maps make a learner's knowledge structure visible—for both the teacher and the learner.

According to Ausubel, Novak, and Hanesian (1968, epigraph) the teacher can plan effective lessons, since "the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly."

The student develops an awareness of his or her own knowledge organization. This process might be enhanced by having the students, in small groups, construct mind maps, since this process forces students to discuss the concepts to be used and the connections to be drawn.

Erroneous connections in a student's knowledge become visible, and the teacher can correct them. The teacher should first ask the student why he or she drew the incorrect connection; the student's explanation might allow more insight into her or his underlying cognitive structure than the simple and reduced representation in the map.

The students' growth in understanding a topic can be checked by asking them to create both a pre- and a post-unit mind map (Hemmerich, Lim, and Neel 1994). The teacher might see, for example, whether supplementary concepts are linked to the topic in a meaningful way.

Mind maps foster creativity.

Everybody can develop a personal style for mind mapping. Mind maps can have different forms and shapes and different colors, symbols, or images. Artistic arrangements are not only allowed but are advantageous. Students gain in creativity, and these mind maps are aesthetically pleasing.

Fostering creativity has a positive effect on mathematical achievement. In schools where emphasis is placed on such creative activities as working on arts, music, or literature, students are also better in mathematics (Svantesson 1992, p. 26).

After a mind map has been completed, it should be redrawn. Knowing the structure of the map and all its components enables students to optimize the artistic arrangements. In addition, students strengthen the represented knowledge.

Mind maps can show connections between mathematics and the rest of the world.

Because a mind map is open for any idea someone associates with the main topic, nonmathematical concepts can also be connected with a mathematical object, as shown in **figure 3.** Thus, students recognize that mathematics is not an isolated subject but is related to many different areas of the rest of the world (Brinkmann 1998, 2001c).

LIMITATIONS

Mind maps are individual graphic representations. Different people have different associations with the same topic, so they draw different mind maps. The correct grasp of the relationships represented in a mind map affords the right associations to the key words. Hence, a person who wants to use a mind map should create it or be involved in its creation.

In spite of its well-structured and ordered contents, a mind map may, at first, seem confusing.

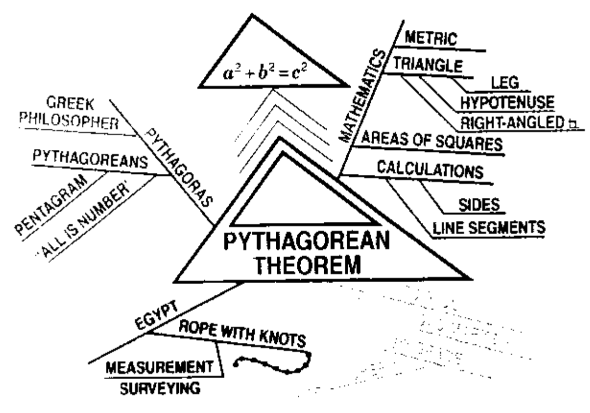

Fig. 3
Nonmathematical objects connected with mathematical objects

In a mind map, each main branch builds up a complex whole with its subbranches. As a rule, connections among the single complexes are not drawn. The clarity of a mind map is thereby increased, but its representation of the existing relationships to a topic is incomplete.

If cross-links are needed, the mind-map technique should be modified, possibly by using colored lines. Depending on the goals, other graphical means of representation might be better.

Concept maps, an example of which is shown in **figure 4,** have a structure similar to that of mind maps, in that they show main ideas and secondary

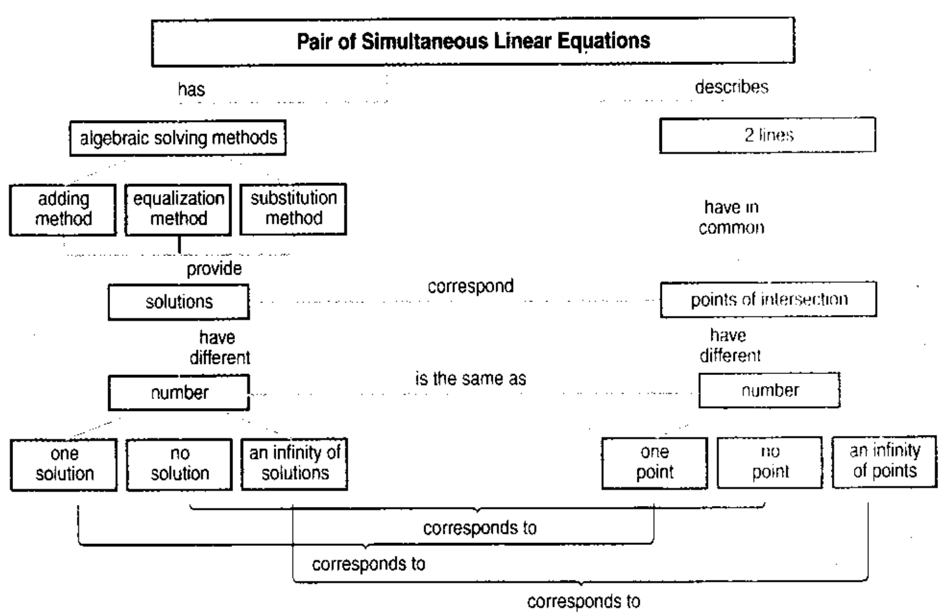

Fig. 4
Concept map on the topic of linear equations

Fostering creativity has a positive effect on mathematical achievement

ideas linked to a topic (Brinkmann 1999, 2001a, 2001c; Novak and Gowin 1984). Here, the topic is positioned at the head of a map and the other concepts are arranged under it on several levels. The more inclusive and general, abstract concepts are higher; and the more specific and concrete concepts are lower. Concepts of different levels but also of the same level are linked by lines if they are related in some way, and every single relationship is described by linking words written on the linking lines, as seen beneath the last row. Thus, a concept map provides much more information on a topic than a mind map, since it represents cross-links between the concepts and since it describes the relations between the concepts with linking words. A concept map, however, does not allow the same display of creativity that a mind map allows.

Mind mapping helped students organize their mathematical knowledge

FINAL REMARKS

Mind mapping has been used very rarely in mathematics education. However, reports about first experiences are positive. Entrekin states, "I found mind mapping to be an effective and delightful pedagogical tool" (1992, p. 444). I have received enthusiastic feedback from teachers who took part in education events that I offered on the topic of mind mapping in mathematics.

Teachers reported that students who were not good in mathematics benefited from mind mapping. These students often first realized connections among mathematical concepts while producing a mind map. They told their teachers that only after having drawn a mind map could they "see" the structure of the respective mathematical knowledge. Mind mapping helped them organize their knowledge.

Several teachers who introduced mind mapping in their mathematics lessons observed that some of their students began on their own initiative to construct mind maps at home, especially when preparing for an examination. One student proudly showed her teacher a mind map that she had drawn as decoration for her notebook. The map represented the contents of that notebook in a structured way.

In my own classes, I found that mind mapping is a technique that is easy to learn and that students see it as a welcome change in mathematics lessons.

The various positive learning effects that mind mapping facilitates should result in enhanced use of this method in mathematics education. The mind map given in **figure 5** shows possible uses of mind maps.

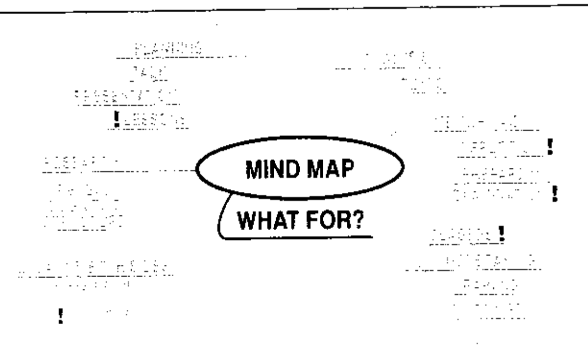

Fig. 5
Possible uses of mind maps

REFERENCES

Ausubel, David P., Joseph Novak, and Helen Hanesian. *Educational Psychology: A Cognitive View.* New York: Holt, Rinehart & Winston, 1968.

Beyer, Maria. "Mind Mapping. Mehr als nur eine alberne Darstellungsform von Gedanken, eher der persönliche Paradigmen-Wechsel des Denkens." *Multi Mind Heft* (January 1993): 34–38.

———. "Mit Mind Mapping zum anspruchsvollen Denk-Management." *Der Karriereberater* (November 1996): 15–24.

Brinkmann, Astrid. "Kategorien der Vernetzungen durch Mathematikunterricht." In *Beiträge zum Mathematikunterricht 1998*, edited by Michael Neubrand, pp. 140–43. Hildesheim: Franzbecker, 1998.

———. "Graphische Darstellungen mathematischer Wissensnetze." In *Beiträge zum Mathematikunterricht 1999,* edited by Michael Neubrand, pp. 109–12. Hildesheim: Franzbecker, 1999.

———. "Mind Maps im Mathematikunterricht." In *Beiträge zum Mathematikunterricht 2000,* edited by Michael Newbrand, pp. 121–24. Hildesheim: Franzbecker, 2000.

———. "Erhebung von Vernetzungen mittels graphischer Darstellungen—Möglichkeiten und Grenzen." *Beiträge zum Mathematikunterricht 2001,* edited by Gabriele Kaiser pp. 121–24. Hildesheim: Franzbecker, 2001a.

———. "Mind Mapping—Eine Methode zur Förderung der Kreativität und Lerneffektivität im Mathematikunterricht." *Lernwelten* (February 2001): Berlin: Pädagogischer Zeitschriftenverlag (2001b): (101–4).

———. "Mathematical Networks—Conceptual Foundation and Graphical Representation." In *Current State of Research on Mathematical Beliefs X. Proceedings of the MAVI-10 European Workshop in Kristianstad, Sweden, June 2–5, 2001,* edited by Riitta Soro, pp. 7–16. University of Turku, Department of Teacher Education, Pre-Print nr. 1, 2001c.

———. "Mind Mapping im Mathematikunterricht—Eine lerneffiziente Abwechslung." *Der mathematische und naturwissenschaftliche Unterricht MNU, Jahrgang 55 (2002), Heft 1.* Köln: Dümmler (2002): 23–27.

Buzan, Tony. *Use Both Sides of Your Brain.* New York: E. P. Dutton & Co., 1976.

Buzan, Tony, and Barry Buzan. [Original English language version: 1993.] *Das Mind-Map-Buch* [The Mind Map Book.] Landsberg am Lech: mvg.

Davis, Philip J., and Reuben Hersh. *The Mathematical Experience.* Boston: Birkhäuser, 1981.

Engel, Andreas K., Peter König, and Wolf Singer. "Bildung repräsentationaler Zustände im Gehirn." *Spektrum der Wissenschaft 9/1993.* Heidelberg: Spektrum, 1993, 42–47.

Entrekin, Virginia. "Mathematical Mind Mapping." *Mathematics Teacher* 85 (September 1992): 444–45.

Hemmerich, Hal, Wendy Lim, and Kanwal Neel. *Prime Time: Strategies for Life-Long Learning in Mathematics and Science in the Middle and High School Grades.* Portsmouth N.H.: Heinemann, 1994.

Hugl, Ulrike. *Qualitative Inhaltsanalyse und Mind-Mapping.* Wiesbaden: Betriebswirtschaftlicher Verlag Dr. Th. Gabler GmbH, 1995.

Kirckhoff, Morgens. *Mind Mapping. Einführung in eine kreative Arbeitsmethode.* Bremen: GABAL, 1992.

Novak, Joseph D., and D. Bob Gowin. *Learning How to Learn.* Cambridge: Cambridge University Press, 1984.

Pehkonen, Erkki. "Zwei Modi des Denkens—Implikationen zum Mathematikunterricht." *Mathematica didacta* 14 (1) (1991): 46–59.

———. "The State-of-Art in Mathematical Creativity." *ZDM* 29 (1997): 63–67.

Poeck, Klaus. "Sprache im Gehirn: eng lokalisierbar?" *Spektrum der Wissenschaft Dossier.* Heidelberg: Spektrum (April 1997): 34–40.

Rubner, Jeanne. "Auf der Spur des kleinen Unterschieds." In *Gehirn, Gedächtnis, Neuronale Netze-Chip Special Aktiv 1996/3,* edited by B. Müller and R. Rittmann, pp. 18–23. Würzburg: Vogel, 1996.

Svantesson, Ingemar. *Mind Mapping und Gedächtnistraining.* Bremen: GABAL, 1992.

Tergan, Sigmar-Olaf. *Modelle der Wissensrepräsentation als Grundlage qualitativer Wissensdiagnostik. Beiträge zur psychologischen Forschung 7.* Opladen: Westdeutscher Verlag, 1986.

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