CONCEPTIONS OF FINNISH AND BRAZILIAN CHILDREN OF THE CONTENT OF THE HUMAN HEAD AND BRAIN

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Abstract: Teachers have a special role when supporting students´ understanding of health and well-being and function of the human body. However, international studies show that the majority of 15-year-old children do not understand the human body as a whole. In Finland, have been carried out only a couple of studies concerning conceptions of children on the structure and function of the body. In Brazil as well, there are a scarcity of studies concerning graphic representation of organs and organ systems at the level of preschool, primary school pupils, and adolescents at secondary school.

This phenomenographic survey is based on the development theory about thinking of children and on the theory of biological thinking. The task is to clarify what kind of conceptions Finnish and Brazilian 4–10-year-old children have of the content of the human head and how the conceptions relate with scientific knowledge. It will be also discussed how a teacher can support understanding and learning of biological knowledge.

A total of 1340 children participated voluntarily in the study. Material consists of drawings and interviews of the children. It was analysed using phenomenographic methods. According to the results, the conceptions varied much even in the same age group. Some children had primitive scientific conceptions, but especially conceptions of the young children were based on imagination. Most children knew that the brain is located in the head. Some of them were able to name parts of the brain and knew something about its function, e. g. that it thinks and directs movements. The conceptions were based on the experiences of the children, were very tenuous and included many mistakes. No one of the children had totally correct knowledge of the structure and function of the brain. When starting a new biological theme it is very important to take into account experiences and everyday conceptions of children. In addition, it should be clarified what the children mean by the biological concepts they use.

Keywords: phenomenography, thinking of a child, everyday conception, science-based knowledge, mental model, brain.

Introduction

For good life we need people who want to act by sustainable way. Teachers have a special role when educating students to understand the fast changing present and the uncertain future. Based on research, quality of knowledge and the way of using it, participation and evaluation should be stressed more in education than currently (Fadel, Bialik, & Trilling, 2015, 25). Sustainability requires health environment and well-heeled people. Keeping in good health requires knowledge of the human body. However, many studies (e.g. Reiss, et al., 2002, 58–63) show that most of the 15-aged students do not understand the structure and the function of the body of their own. In Finland, only a couple of studies concerning conceptions of children of the human body and no studies focused on conceptions of children of the human head and brain have been carried out until now. There are few studies concerning the internal anatomy of the human body in Brazil (Bartoszeck et al., 2008 a., b; 2010; 2011; Bartoszeck & Bartoszeck, 2012).

In this article, we describe how Finnish and Brazilian aged 4–10 children understand the content of the human head and especially the location, and the structure and the function of the brain. Studies of the conceptions of children give information how children perceive themselves as a biological being and support thus teachers in their work.

In the study, thinking of children is approached based on the cognitive development theory of Piaget (Piaget & Inhelder, 1977; Piaget, 1988) and the theory concerning biological thought of children by Carey (1987). According Piaget (1988), 2–7-aged children are in the pre-operational stage. After that the concrete operational stage continues until age 11. During these stages, children understand objects and events based on their sense observations and therefore they have difficulties to understand such abstract items as the content of the head. Carey (1987) states that children understand the function of the human body first as a wholeness and not until later on the meaning of separate organs and organ systems.

The study is a phenomenographic, qualitative survey with quantitative features. It describes (Niikko, 2003, 16) how Finnish and Brazilian children understand biology of human beings, especially the content of the head and the brain. It is discussed, how scientific the conceptions of the children are and how teachers can support their students in understanding and learning of biological information and concepts. Scientific knowledge consists of information what is justified and produced using methods what are approved by scientific community (Ronkainen et al., 2011, 16).

A total of 1340 pupils participated voluntarily in this study, 131 from Finland and 1209 from Brazil. From the Finnish children 29.3 % were aged 4–6 and 70.7 % aged 7–10 and from the Brazilian children aged 4–6 comprised 21.3 % and aged 7–10 comprised 78.7 %. The material included the drawings of the children concerning the content of the human head and the interviews based on the drawings. The drawings were used because most children could barely write the name of the biological structures. The analysis of drawings is an useful method when studying conceptions of children (Johnson & Wellman, 1982; Reiss et al., 2002; Bartoszeck & Bartoszeck, 2012; Rabello, 2014). Through interviews, we wanted to get more information of the ideas of the participants and to secure that the drawings were understood in the right way. The data was analyzed by the phenomenographic methods. The research questions are:

1. What kind conceptions do Finnish and Brazilian children aged 4–10 have concerning the content of the human head, and especially the location, the structure and the function of the human brain?
2. How does the scientific knowledge of the human head and the human brain appear in the conceptions of the children?

3. How can a teacher support his/her students in understanding and learning of biological information and concepts?

Learning and thinking skills on the 21st century

One of the international goals for future, widely agreed upon may be, is the construction of a sustainable society (Fadel, Bialik, & Trilling, 2015, 1–6). Until now, the goal has not been achieved. Worry about future, marginalization, and stressful lifestyle foster indisposition not only for adults but also for youngster (Luopa et al., 2014, 3). Healthy lifestyle and life habits are ways to create better future but they can not be taken for granted instead children should be educated to understand that.

Teachers have a key role when supporting students to understand scientific information concerning human being, environment, community, and society (Vauras et al, 2014; Volet et al., 2013). According to Fadel et al. (2015, 25), it should be emphasized more than nowadays the next educational issues: 1) what we know and understand, 2) how we use what we know, and 3) how we behave and engage in the world.

Learning is more efficient, if students are initiated into the acquisition of scientific knowledge (Vauras et al., 2014). Different learning environments support self-efficacy, autonomy, engagement, and meaningful learning (Turner & Fulmer, 2013), and current and contextual tasks foster creativity and flexibility. Collaborative learning can be supported e. g. by searching information (Volet, Summers, & Thurman, 2009*)* and producing knowledge in groups (Khosa & Volet, 2014), by evaluating learning, action, and knowing together (Volet, Vauras, Khosa, & Iiskala, 2013), and by scaffolding learning processes (Vauras, Kinnunen, Kajamies, & Lehtinen, 2013). Getting over difficulties and failures and development of emotional life should also be emphasized (Vauras, Lehtinen, Volet et al., 2014).

The curricula of kindergartens and primary schools in Finland and in Brazil

In Finland, the goal of early childhood education is to foster balanced growth, development, and learning of children. Based on scientific orientation, children are familiarized with nature phenomena through experiential learning methods (Sosiaali- ja terveysalan …, 2005, 11, 28). How well and how much children get information of the human body depends on every teacher because teachers create local curricula.

In the new Finnish national curriculum for basic education (Opetushallitus, 2014, 2015, 10), students' personal development, respect of life, human rights, and education for sustainable life habit form the basis of education. Local curricula can be structured by teachers either utilizing traditional, subject-based knowledge or modern integrative, interdisciplinary knowledge. Value-based learning should be supported through co-operation with home. Learning environments and methods should be selected so that they support development, learning, and co-operation of students based on the goals. It has also been expressed that variation of experiential and action learning methods stimulate creativity, autonomy, motivation, and collaborative learning of students. Students should be guided both individually and in groups in their goal settings and searching solutions for problems. They should have possibilities to participate in action of their community. In addition, it is mentioned that senses, observations, and description of observations and action are crucial for learning and development of cognitive skills. (Opetushallitus, 2014, 2015, 10–17.)

Knowledge of the human biology broadens and deepens step by step from one grade to another. During the grades 1–6 (aged 7–12), the biology studies belong to the environmental studies and

during the grades 7–9 (aged 12–15) to biology. The environmental studies include beside biology also geography, physics, chemistry, and health education. Education is based on respect for nature, valuable life, and human rights. Teaching is based on scientific knowledge as a goal for cognitive development. It is also mentioned that children are a part of their living environment and they should be guided to know and understand phenomena in nature and built environment, themselves and other human beings, and the meaning of health and well-being. (Opetushallitus, 2015, 239–241.) In the grades 7–9 as a goal is to support students to understand life and evolution, functions of the human body, and basics of genetics through experimental learning methods. In addition, factors affecting growth, development, and health and effects of genome and environment on the development of features should be discussed. (Opetushallitus, 2015, 379–381.)

In Brazil, according to the National Education Plan the early childhood education plan is for 0–5 year-old children and divided in two groups: nursery school (aged 0–3) and kindergarten /preschool (aged 4–5) which is compulsory education. The Federal Council of Education which belongs to the Ministry of Education establishes a core curriculum for the kindergarten consisting of rudiments of reading and writing of Portuguese language, counting numbers, and basic notions of history, geography, science, arts and physical education, whereas for the primary school (aged 6–14) besides the same subject matters in a more advanced fashion, it also includes a foreign language (Barreto, 2003; Becker, 2007).

Brazilian legislation allowed for two options within secondary school (aged 15–17), the ”scientific” with emphasis on the natural sciences, and the ”classical” with emphasis on the humanities. However, the 1996 Education Law abolished these differences. This law created a list of what all Brazilian pupils needed to study: Portuguese language and mathematics, the physical and natural world, the social and political reality, the arts, physical education, history of Brazil, and a foreign language (adapted from Schwartzman, 2011).

Cognitive skills develop in stages

According to Piaget, cognitive development of a child is based on maturation of the nervous system and experiences of an individual. The development stages follow each other always in the same order but the individual age and duration of a stage varies depending on intelligence and the social-cultural environment of a child. Every development stage forms a basis and a requisite for the next stage. Piaget divided the cognitive development into four stages: sensorimotor stage (from birth to aged 2), pre-operational stage (from aged 2 to aged about 7), concrete operational stage (from aged 7 to 11), and the formal operational stage (from aged 11 to aged about 15, expanding into adulthood). (Piaget & Inhelder, 1977, 94–147; Piaget, 1988, 99–107.)

During the sensorimotor stage, the cognitive structures develop. They form the basis for observations and cognitive skills. The basis of emotional reactions also develop at this time. (Piaget & Inhelder, 1977, 13.)

In the pre-operational stage, a child learns to name objects and understand their meaning. E. g. in biology education, it is thus important to discuss biological terms and concepts. A child is able to tell about his/her action and to predict acts. He/she uses symbols in his/her plays and interprets reality using imagination. He/she has the belief that everything that exists has some kind of consciousness and he/she replaces logic with intuition. Thought and use of concepts are based on sense observations. During the pre-operational stage, a child is step by step able to co-operate and to become socialized. (Piaget & Inhelder, 1977, 61–118; Piaget, 1988, 13–53.)

During the concrete operational stage, a child starts to use operations. Operations are actions

what are internalized and recalled. (Piaget & Inhelder, 1977, 94–128.) A child aged 7–8 is able to classify, list, and measure objects and he/she can make logic conclusions; but the objects of the operations are concrete not verbal assumptions or statements and therefore a child is not able to understand symbolic language. Different biological tasks including pictures, photos, and organ models are useful when developing classification skills of children. At age about 7 year-old, a child is able to work independently and co-operate with other people (Piaget & Inhelder, 1977, 50–128; Piaget, 1988, 70–102).

During the formal operational stage, a 14–15-year-old child is able to understand that reality is formed by various combinations of different objects, factors, ideas, and statements. He is able to think logically by using abstract objects. He is also able to make conclusions concerning the statements what he/she does not believe or what he/she thinks to be only assumptions. In addition, he/she is able to use abstract concepts and to construct theories. (Piaget & Inhelder, 1977, 126–143; Piaget, 1988, 87–90.) Through formal operations people can understand the function of the human body, because the biological concepts are observations and ideas what are seen to be true.

The cognitive development theory of Piaget has been criticized e. g. by saying that the participants of Piaget's studies were children of Swiss, middle-class families and therefore the results cannot be generalized (Kronqvist & Pulkkinen, 2007, 17). The cognitive development theory is argued to be too holistic, because all skills of a child do not develop at the same time (Bandura, 1977). As a weakness of the theory it has also been said to be that the theory is fastened to the biological age (Kronqvist & Pulkkinen, 2007, 87). Many researchers have argued that Piaget underestimated the cognitive skills of children and overestimated those of youngsters. Researchers have also shown that all adults do not reach the formal operational stage. (e.g. Hautamäki, 1984, 121; Lehtinen et al., 2007, 109.) In addition, Piaget did not take into account social environment although social factors affect cognitive development (Bandura, 1977).

Piaget himself has commented the criticized views. He has been worried about generalization of his results and has stressed that ages are average ones and not fastened to the age of an individual child (Piaget, 1988, 99). In the study, we use Piaget's cognitive development theory when discussing about thinking of kindergarten and primary school children. At kindergartens and schools, a child learns new concepts and relations between them. A concept means a category of objects, things, or actions what is formed and named based on the common attributes of items. Through concepts a child organizes his/her world and structures his/her world view. (Laine, 1984, 11; Havu-Nuutinen & Järvinen, 2002, 139–140.) The participation of a child in action of his/her community requires that meaning of the concepts used by him/her are similar enough with the concepts used in his/her community (Hirsjärvi, 1983, 102; Laine, 1999, 29–31; Brotherus et al., 2002, 80.) The development of concept understanding is a core area in kindergarten and primary school education.

The development of biological thought of children

Carey (1985; 1987) has studied the development of biological thought of 4–10-year-old children. Thinking processes start to change at age about 10. First a child understands the connection between the human body and life. He/she knows that the function of the body is necessary for all animals. However, he/she does not understand similarities between the human body and the bodies of other animals. Later on, a child understands that the human beings are mammals and starts to value the structure of the human body. Finally, he/she understands that some functions are similar both in the human and animal organs and organ systems.

First a child understands the body as a wholeness and not until later the meaning of the single

organs. At age10, a child knows the names of some internal organs and understand that the internal organs affect life, growth, and reproduction. The development of understanding is based on changes in conceptual thought what means that a child is able to differentiate and integrate items. (Carey, 1987, 184–185.) Differentiation means e. g. that a child is able to name single animals and plants and to separate animal and plant species; integration means e. g. that a child knows that all animals and plants are organisms. This kind thinking does not require modifying of any theory. Later on, new conceptions with new concepts develop on the basis of former conceptions. (Carey, 1985, 189–201.)

The concepts are the constructions, what develop step by step from informal concepts towards scientific concepts. The former ones are based on experiences of a child and are concrete, the latter ones are learned through education, and understanding of them requires that a child is able to think abstractly. (Vygotski, 1982, 154–160.) The concepts concerning the human brain and also other biological concepts are scientific in the meaning expressed by Vygotski.

Conceptual thinking is based on a mental image of a concept or a mental model of an object and determination of it (Vinner, 1991, 65–73). The development of a mental image is based on a direct stimulus. The determination of a concept strives for an explanation what is useful when determining new concepts. When concepts develop the mental image of it can remain unchanged, blend in the determination or stay a part of it. Single concepts form concept systems. The development of concept systems requires that a child has concepts what can be affected through education. (Vygotski, 1982, 169.) In Finland, teaching of the human body at kindergartens depends on teachers (Sosiaali- ja terveysalan ..., 2005, 11, 28). In the Finnish elementary schools, knowledge of biological concepts broadens and deepens step by step, when anatomy and physiology of the human body are studied starting from the environmental studies in the primary schools up to the biology education in the lower secondary schools. (Opetushallitus, 2014, 2015, 132, 241, 381).

The Brazilian school science biological curricula proposes for the kindergarten years (aged 4–5) seasons of the year, invertebrate and vertebrate animals, flowers and trees. At grades 1 to 3 (aged 6–8) introduction to organ and organ systems, growth of human beings, and grades 4 to 5 (aged 9–10) animals in relation to the environment and human beings; basic concepts of bones, muscles, nervous system, and sense organs. Children enrolled at grades 6 to 8 (aged 11–12) study comparative basic animal morphology and physiology including digestion, respiration, circulation, excretion, movement, sense organs and nervous system. On the other hand, at grades 9 to 10 ((aged 13–14) pupils are taught about human anatomy and physiology, specially locomotion, endocrine organs, neural coordination, sexual education, diseases, and drugs (Bartoszeck et al., 2008)

Teaching and learning biology is not easy because a child explains phenomena and issues through his/her intuition if he/she does not have knowledge of scientific information. A teacher should therefore clarify how informal knowledge of a child relates with scientific knowledge and try to find out how he/she can support a child in learning and understanding of scientific concepts.

Conceptions of children of the human body and the content of the human head

In many countries, studies concerning conceptions of children on the human body and the content of the human head have been carried out (e. g. Gellert, 1962; Reiss et al., 2002; Zoldosova & Prokop, 2007; Bajd & Ivekovič, 2010). Instead in Finland, as far as we know, only the article of Jeronen et al., (2010) is published until now. Our study is also the first one where conceptions of Finnish and Brazilian children are compared with each other. In the previous

studies, study material has included drawings, questionnaires, and interviews. Comparison of the results of the studies is difficult due to the different guidelines for children in the study situations and different research methods, and because cultural differences have affected interpretations of the results. However, a common conclusion can be drawn; it is that knowledge of the children of the human body is insufficient and misunderstandings are usual in all age groups. (Prokop, Fančovičová, & Tunnicliffe, 2009.)

Conceptions of children on the human body

Most changes in the quantity and quality of knowledge happened at age 4–9 in Gellert's (1962) study where 96 American 4–16 year-old children participated in. The youngest children described body based on their experiences. As most important organs and external structures they mentioned were feet, nose, and bones because they can palpate them. The children aged 7–8 knew heart based on its beat. The under 9-year-old children mentioned that heart is connected with emotions but they did not know that it belongs to the circulatory system. The children aged 9–10 were able to list internal organs such as stomach, urinary bladder, and lungs, but they did not understand relationships between them. They knew that the lungs clean blood, and the 11-year-old children knew something about the digestion. Not until at age 12–16, the children had knowledge of the function of organs and organ systems.

Beside maturation and education the conceptions of children are also affected by cultural differences. Reiss et al., (2002) studied conceptions of the human body of 7–15-year-old children from 11 countries through the drawings by children. The children mostly described respiratory and digestion organs, and the skeleton. From aged 7, the children from Brazil, North-Ireland and Taiwan knew scientific knowledge more than their coevals in other countries. Most of 15-year-old children did not understand the human body as a wholeness although the 7-year-old children already knew single organs. According the researchers, the differences of the conceptions are based on differences of the educational systems and families. (Reiss et al., 2002, 58–63.)

Zoldosova and Prokop (2007, 239–246) studied conceptions of 6–10-year-old children concerning the development during pregnancy. In total 20 children participated in the study. Based on their drawings and interviews, the researchers showed that the conceptions were different both from the level and the content even in the same age group. According the researchers, the main reasons for this variation are quality and quantity of information sources and temperament of a child, i. e. how curious, interested, and open a child is.

Bajd and Ivekovič (2010) studied effects of teaching on conceptions of children. The participants were at age 5–6 (n=72). The children described before and after teaching period what happens to an apple when it is eaten. The information gathered at the beginning of the study was taken into account when planning a teaching period of the digestion. The digestion processes were taught using action learning methods for some weeks. Before teaching 51 % of the children drew a whole apple going through the digestion system, after the teaching period only 18 %. Before teaching 14 % of the children were able to draw the digestion system, afterward 42 %. Different activities supported understanding of the digestion processes. The children had some correct knowledge but plenty of wrong knowledge of the human body in both situations. According to the researchers, a reason is that we can not see inside the body. (Bajd & Ivekovič, 2010, 31–37.)

Jeronen et al. (2010) clarified conceptions of North-Finnish, 7–8-year-old children on the human body. Based to the drawings and interviews of 20 children, it was shown that the children hardly have knowledge of the human organs. Some children had informal knowledge and some simple scientific knowledge. The conceptions were based on concrete observations and misconceptions were common. Drawing of the bones was difficult for every one. The connections between the

skull, backbone, ribs, and limbs were unknown. About 50 % of the children draw muscles into the hands and feet and knew that the muscles are needed for movements. All participants knew the heart and the most of them were able to tell something about the digestion. (Jeronen et al., 2010, 145–148).

The studies above show that children aged 4–16 know best the organs which they can palpate. They have knowledge of single organs but they do not understand the anatomy and physiology of the body as a whole.

Conceptions of children of the human head and the human brain

There is a scarcity of studies concerning the conceptions of children of the content of human head and the human brain. Johnson and Wellman (1982) studied conceptions of 3–14-year-old children of the human brain. The 3-year-old children did not know where the brain is located in the head but some of aged 4 and 5 knew. The youngest children knew that the brain is needed for thinking but they did not understand that it is needed also when telling stories or shaking the head. Some of the 4-year-old children had conceptions of the brain functions. The most of over the 5-year-old children understood that the brain is needed e. g. when doing homework. Not until aged about 10, the children understood that the brain is needed in all functions of the body. The children aged 8–11 knew that the brain has to do with behaviour, and 14-year-old children understood that the brain is needed in all actions and behaviour. (Johnson & Wellman, 1982, 222–234.)

Bartoszeck and Bartoszeck (2012) studied conceptions of Brazilian 4–10-year-old children of the content of the human head and discussed how the conceptions and the descriptions of the brain develop. The children draw of the content of the human head and some of them were interviewed based on their drawings. The age and gender of the children were taken into account when categorizing the drawings using the following types: the mental image model, hydraulic model, the dog bone model, the enteric model, the epithelial model, the calotte (skull cap) model, and the neuroanatomical model (Table 1).

Table 1 The categorization of the material (Bartoszeck & Bartoszeck, 2012, 128–133).

Types	Characteristics
Mental image model	The brain is described by mental images.
Hydraulic model	The brain is described by lines as the flow of a small brook.
Dog bone model	The brain is described as dog bones all over the skull.
Enteric model	The brain is described by tubes or thick threads similar to the intestine on the top of the skull.
Epithelial model	The brain is described as patches similar to the epithelial tissues.
Skullcap model	The brain is described on the top of the skull.
Neuroanatomical model	The brain is described by right and left hemispheres.

The drawings of children included all models mentioned above. Most children described the brain using lines in accordance with the hydraulic model. Some children described the content of the head with mental images or dog bones. However, although mental image drawings still persisted during the grades 2–4, a drop on the percentage of the hydraulic model and the dog bone model was noticed (p. 131). Some of the older children draw the brain in accordance with

the enteric or epithelial model. The drawings in accordance with the skullcap model were done more by the older children than the younger ones. Some children draw the brain in accordance with the neuroanatomical model. The children before the second grade did not described the brain by this way. The interviews showed that although some children did drawings in accordance with the neuroanatomical model, they did not make a clear distinction between the biological structure of the human brain from thoughts. (Bartoszeck & Bartoszeck, 2012, 130–133.)

The studies above show that the conceptions of children on the content of the human head and the human brain differ from each other. The younger children describe more often than the older ones the brain through functions and the older ones through the structure of the head and the brain.

Material and methods

The study is a phenomenographic qualitative survey with quantitative features (Hirsjärvi et al., 2009, 135–137; Morse, 2010, 339–352; Collins, 2010, 353–378). In the phenomenographic study, conceptions based on individual experiences are described (Niikko, 2003, 16–46). A conception is the sum of a person's ideas and beliefs concerning something constructed by an individual himself/herself (Ahonen, 1994, 116–117). Same concepts get different meanings depending on cultures and therefore phenomena and items are interpreted and understood by different ways (Häkkinen, 1996, 24–25). In the study, qualitative differences of conceptions of Finnish and Brazilian children (aged 4–10) concerning the content of the human head and the human brain are described.

Larsson (1986, 14–20) divides the phenomenographic studies into subject educational studies, general pedagogical studies, studies measuring effectiveness of schooling, and other than pedagogical studies. The study belongs to the subject educational studies, what concern knowledge of scientific concepts and misconceptions. These kinds of studies are important because teachers are able to support their students only if they understand how children understand scientific phenomena (Häkkinen, 1996, 16–17). According to Aarnos (2010, 180), the phenomenographic approach is one of the best approaches when studying conceptions of children.

In total 1349 Finnish and Brazilian children (4–5-year-old n= 161, 6–7-year-old n=321, 8–10-year-old n=867) participated voluntarily in the study (Table 2).

Table 2 Distribution of the number of the Finnish and the Brazilian children by age level.

Grade/ages	Finnish N	Brazilian N
Kindergarten I (aged 4)	7	30
Kindergarten II (aged 5)	10	114
Kindergarten III (aged 6)	24	113
Primary school (PS) 1st grade (aged 7)	15	154
Primary school (PS) 2nd grade (aged 8)	32	225
Primary school (PS) 3rd grade (aged 9)	22	268
Primary school (PS) 4th grade (aged 10)	21/131	305/1209

The number of the Finnish children is small because kindergartens and schools should be located

near the university because as low costs as possible, and in the near surrounding, there were only a couple of kindergartens and schools what wanted to participate in the study. However, the sample is large. According to Larsson (1986, 31), the number of participants is typically 20–50 participants in a qualitative study. The material included the drawings of the kindergarten and primary school children and the interviews based on these drawings. In one of the Finnish primary schools, the children had learned a topic of human being including the human body just before the study.

In every study place, the researchers asked the students to write down their first names, age on the top of a blank A4 sheet of paper with a black pencil. Next, pupils were asked to draw ”what they think they have inside their head”. An outline of the head and a portion of the neck were drawn on the blackboard of the classroom or in some cases onto the papers to serve as a model. Alternatively, some pupils preferred to use a profile of a head what was also accepted. The students were given 10–15 minutes to complete their drawings. Many of them spontaneously labeled the biological structures on the outlines. The auxiliary teacher wrote labels to the younger children when requested. The fieldwork was conducted in whole class settings.

Prokop and Fancovicová (2006) have argued that drawings do not express exactly what children know about the human body. Therefore the children were interviewed based on their drawings immediately after the drawing situations. Through the interviews we wanted to secure that we get the answers concerning our research questions and that we understand the drawings of the children in the right way. Using interviews it is possible to come closer to participants meanings and to understand better their conceptions (Puusa, 2011, 78). For safety feeling of the children (Hirsjärvi et al., 2009, 211), in Finland the teachers divided the children in the groups of 2–4, and the interviews were carried out in the familiar and peaceful places (Eskola & Vastamäki, 2001, 29). At the beginning of every interview, the sequence of events were told to children (Hirsjärvi & Hurme, 2000, 47).

The Finnish participants were grouped on kindergarten, preschool and primary school, and based on the attending grades and enumerated according to the gender and age of the children. The interview material was analyzed by the phenomenographic methods (Niikko, 2003) and the drawings by categorizing them quantitatively (Greene ym., 1989) according to the description of Bartoszeck and Bartoszeck (2012) (Table 1).

In a similar way, the Brazilian participants were grouped on kindergarten, preschool and primary school, and the attending grades corresponding to their ages. Drawings where collected and a random sample of the children were interviewed to explain the meaning of their drawings. Classification and analysis of the drawings was carried out independently by the authors according to the model types (Table 1.) The goal of the study was not to draw any statistical conclusions but to find out how children at different ages describe the human head and the human brain.

Results

The results point out some differences between the conceptions of the children from the participating countries concerning their thinking about the content of the human head and the structure and the function of the human brain. The conceptions of the children are presented based on the frequency of the description categories (Niikko, 2003, 37–38). Most conceptions concern the human brain and these conceptions are presented first. Secondly are presented the conceptions of blood vessels and thirdly the conceptions of nerves. The last presentations concern other conceptions of the contents of the human head.

Conceptions of the location and the size of the human brain

According to Johnson and Wellman (1982), some 4–5-year-old children know that the brain is located in the head. The Finnish results support this observation. Only three of the Finnish participants did not describe the brain. One boy aged 8 gave back a blank paper and told that he has no idea about the content of the human head. Another 9 year-old boy had drawn a ring, and he was not able to tell what it means. The third boy aged 9 had drawn the flag of his mother-country and told that he misses his mother-country and that he does not have any knowledge about the human brain. Some Brazilian children drew representations of their own resemblances.

The Brazilian results revealed that the children from kindergarten up to the 4th grade of primary school were adepts of historical models of the brain and thus a rubric was developed by the authors based on their previous experience when dealing with children drawings in other biological domains, to allocate a grade to the drawings (Table 3).

Table 3 The rubric used to allocating a grade to the drawings of the Finnish and Brazilian children.

Level	Criteria
1.	Unrecognizable scribbling.
2.	Lines, entangling of threads spread all over the skull.
3.	Amoebic shape sphere with stripes or spokes or spiral lines.
4.	Connecting tubes all over the skull.
5.	Sphere-like or cranial ”callote” shaped brain, connected or not to sense organs.
6.	Roughly represented cerebral hemispheres with cerebral circumvolutions at approximate position, gross anatomical brain structure.

Concerning the Finnish results, on the level 1 were 71.42% of the drawings made by the 4 year-old boys and same aged girls achieved the level 2 (14.29%) and the level 3 (14.29%). The boys aged 5 years had values for the level 1 (20.0%), and the level 2 (80.0%) respectively. The same age girls had the level 1 (80.0%) and the level 2 (20.0%). On the other hand, the 6 year-old boys achieved the level 1 (57.14%), the level 2 (7.14%), mental image model (7.14%) the hydraulic model (21.43%), and the enteric model (7.15%) (Table 4). The same age girls had the level 1 (30.0%) and the hydraulic model (20.0%), the dog bone model (20.0%) and the skullcap model (30.0%).

The conceptions of the brain depicted by the 7 year-old boys were the hydraulic model (20.0%), the enteric model (40.0%), and the skullcap model (40.0%), whereas the girls same aged were on the level 1 (10.0%), the hydraulic model (10.0%) and the skullcap model (80.0%).

On its turn, the 8 year-old boys still presented drawings at the level 1 (9.09%) and other historical models such the hydraulic model (27.27%), the enteric model (27.27%), the skullcap (9.09) and the neuroanatomical model (27.28%).

Almost the same trend was observed for the girls at the same age: the mental image model (14.28%), the skullcap model (14.28%) the hydraulic model (38.09%) and the enteric model (9.55%), and the neuroanatomical model (23.80%).

The conceptions of the brain represented on the drawings by the 9 year-old boys were: the mental image model (12.5% respectively), the hydraulic model (75.0%), and the neuroanatomical model (12.5%), whereas the girls same aged presented the mental image model (30.76%), the hydraulic model (7.69%), enteric model (23.07%), and the neuroanatomical model

(38.46.0%).

The results of the last age group, the 10 year-old boys, which presented the epithelial and the mental model (7.6% each), hydraulic model (53.94%) and neuroanatomical model (30.86%), whereas the girls same age presented the hydraulic model (12.5%), the enteric model 25.0%) and the neuroanatomical model 62.50%).

Table 4 Classification of drawings of the Finnish children according to the model types (%).

Grade/model	Mental image	Hydrau-lic	Dog bone	Enteric	Epithe lial	Skull cap	Brain hemisphere	Un-classified	N
Kindergarten I (nursery)	-	-	-	-	-	-	-	100.0	7
Kindergarten II	20.0	-	20.0	-	-	-	-	60.0	10
Kindergarten III	4.16	20.83	8.33	4.16	-	12.5	-	50.0	24
1st grade	-	13.33	-	13.33	-	66.66	-	6.66	15
2nd grade	9.37	34.37	-	15.62	-	12.50	25.0	6.25	32
3rd grade	22.72	31.81	-	13.63	-	-	31.81	-	22
4th grade	4.76	42.85	-	9.52	4.76	-	38.09	-	21/131

Concerning the Brazilian results, there were 48 % from the drawings made by the 4–5 year-old boys and 65 % from the drawings made by the same aged girls were on the level 1. 49 % of the 6 year-old boys were also on the level 1, whereas 32 % of the same aged girls were on the level 3 (amoebic shape). Most conceptions of the brain of the youngest children represented on the drawings correspond to historical models (mental image model) (Table 5). However, many 7 year-old boys achieved level 3 (44 %) and girls same aged contrary to expected level 1 (49 %), whereas the opposite was noticed for pupils 8 year-old where boys achieved level 1 (50 %) and girls level 3 (62 %). On the other hand, the same trend was noticed for older children which achieved level 3. Thus, 9 year-old boys had a frequency of 46 % and girls 60 %, and both 10 year-old boys and girls had a frequency of 50 %. Although mental image drawings still persist in all range of ages, there is a drop on the percentages of hydraulic model and bone model and a meaningful increase as the brain shaped as a ”callote” (level 5 of structural complexity). But even so, children 9 year-old poorly represented the brain as distinguishable brain hemispheres as described in level 6 (7.8 % of the total sample) (Table 5).

Table 5. Classification of drawings of the Brazilian children according to the model types (%).

Grade/ model	Mental image	Hydraulic	Dog bone	Enteric	Epitelial	Callote	Brain hemisphere	Unclassi fied	N
Kinder-garten I	-	23.33	13.33	-	-	-	-	63.33	30
Kinder-garten II	1.75	22.8	17.54	-	0.87	7.89	-	49.12	114
Kinder-garten III	2.91	40.77	10.67	5.82	-	1.94	-	43.68	113
1st grade	2.60	15.60	2.60	4.50	3.20	20.10	-	51.2	154
2nd grade	6.20	12.80	3.50	6.20	3.10	28.88	0.80	37.7	225
3rd grade	2.20	6.70	-	6.70	6.30	50.30	2.90	23.60	268
4th grade	4.20	4.50	0.60	9.10	2.20	52.70	7.80	18.30	305/1209

Conceptions of the structure of the human brain

Like in the study of Bartoszeck and Bartoszeck (2012), the drawings of the Finnish and the Brazilian children included all models. The children aged 4–5 described mostly the brain in accordance with the mental image model (Figure 1). They draw fancy creatures, animals or every-day things into the head.

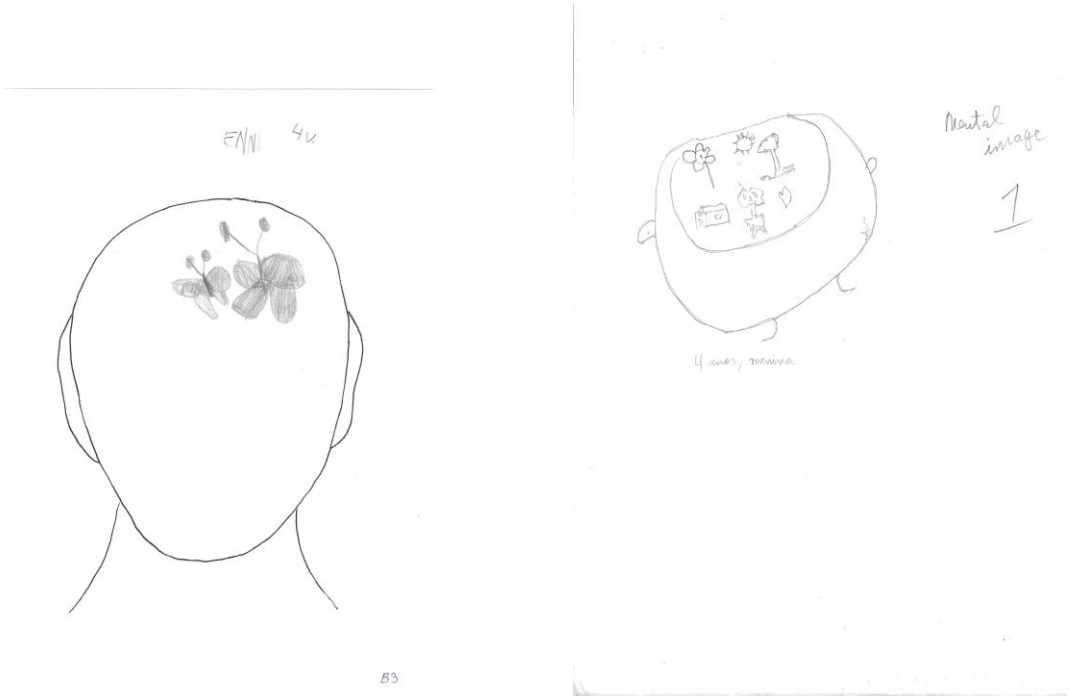

Figure 1 Examples of the drawings by 4–5-year-old children representing the mental image model.

From the descriptions of the brain, it can be observed the effort of a child in the preoperational stage to replace his lacking scientific knowledge intuitively by using his/her imagination (Piaget & Inhelder, 1977, 61–118; Piaget, 1988, 13–53).

Drawings in accordance with the hydraulic model did most the children aged 8–10 (Figure 2). Also many 6–7-year-old children did this kind of drawings, but 4–5 aged children had only few drawings in accordance with the hydraulic model.

Figure 2 Examples of the drawings by 8–10-year-old children representing the hydraulic model.

Many of the 4–5 aged children described the brain in accordance with the dog bone model. The children who described the brain in accordance with the hydraulic model or the dog bone model are in the pre-operational stage. These children in the concrete operational stage perceived the content of the head palpating it (Piaget & Inhelder, 1977, 127–128). During the interview two Finnish 6–7-year-old children who drew dog bones into the head, told that they mean with them the skull not the brain (Figure 3).

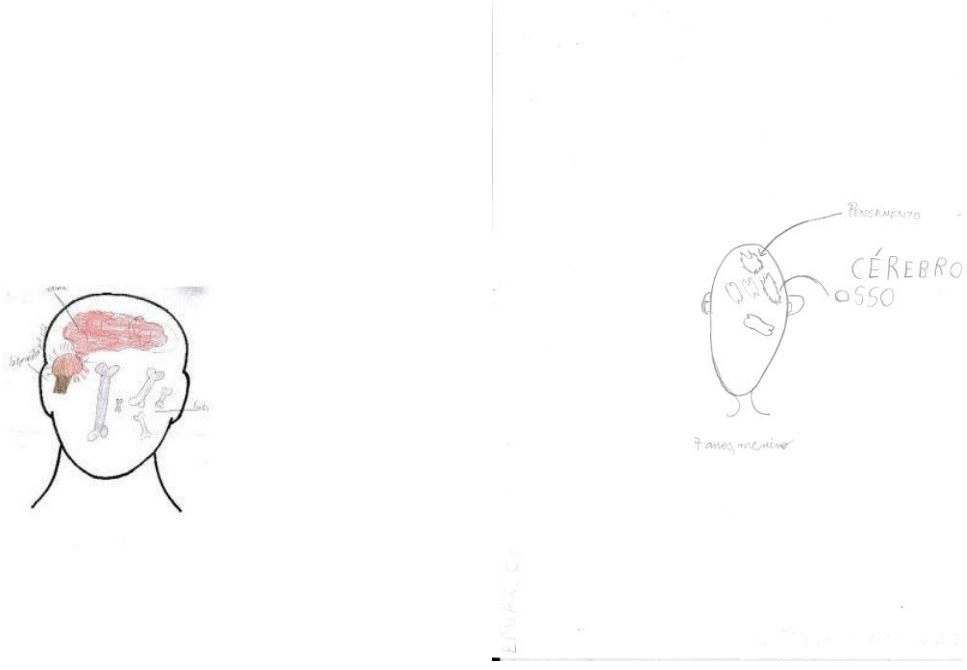

Figure 3 Examples of the drawings by 6–7-year-old children representing the dog bone model.

Some children described the brain in accordance with the enteric model (Figure 4) and the epithelial model (Figure 5).

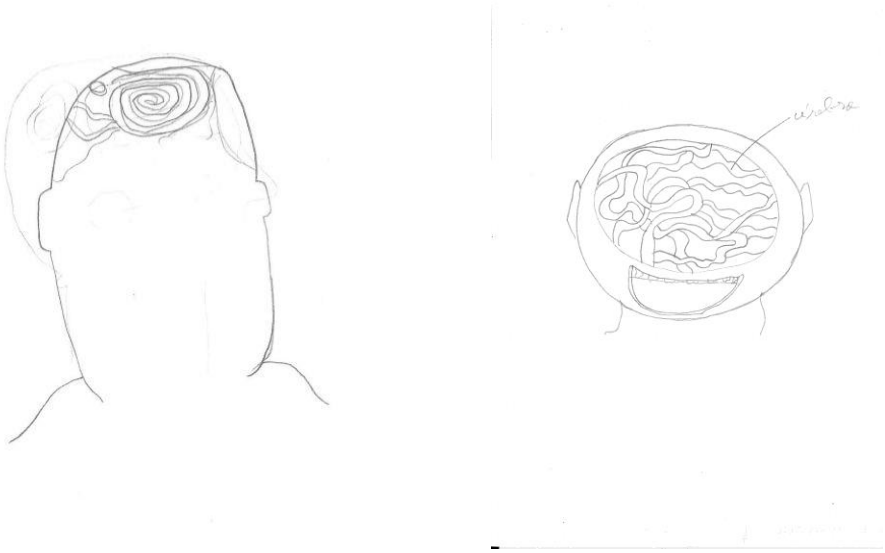

Figure 4 Examples of the drawings by 8–10-year-old children representing the enteric model.

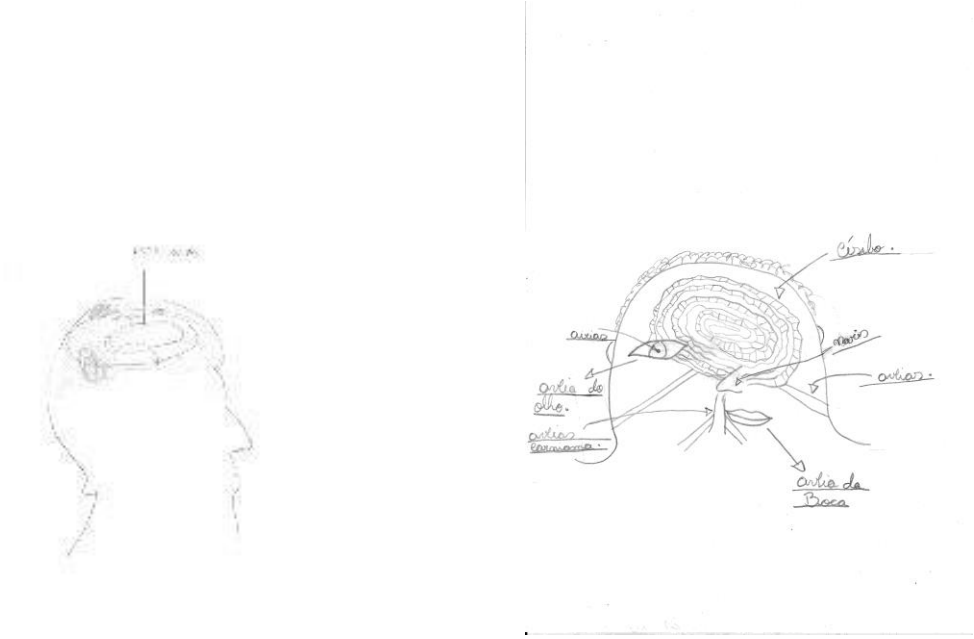

Figure 5 Examples of the drawings by 8–10-year-old children representing the epithelial model.

Based on the descriptions in accordance with the enteric model and epithelial model it was seen that many children have conceptions what are comparable with the gyri of the cerebrum (Langley, Telford, & Christensen, 1980, 226).

The most drawings in accordance with the skullcap model (Figure 6) were done by the 8–10-year-old children. Only children aged 4–5 did not draw in accordance with the skullcap model. The result support the study of Bartoszeck and Bartoszeck (2012). Based on the results, it can be seen that most children aged 6–10 have scientific knowledge concerning the location of the brain (Langley et al., 1980, 226).

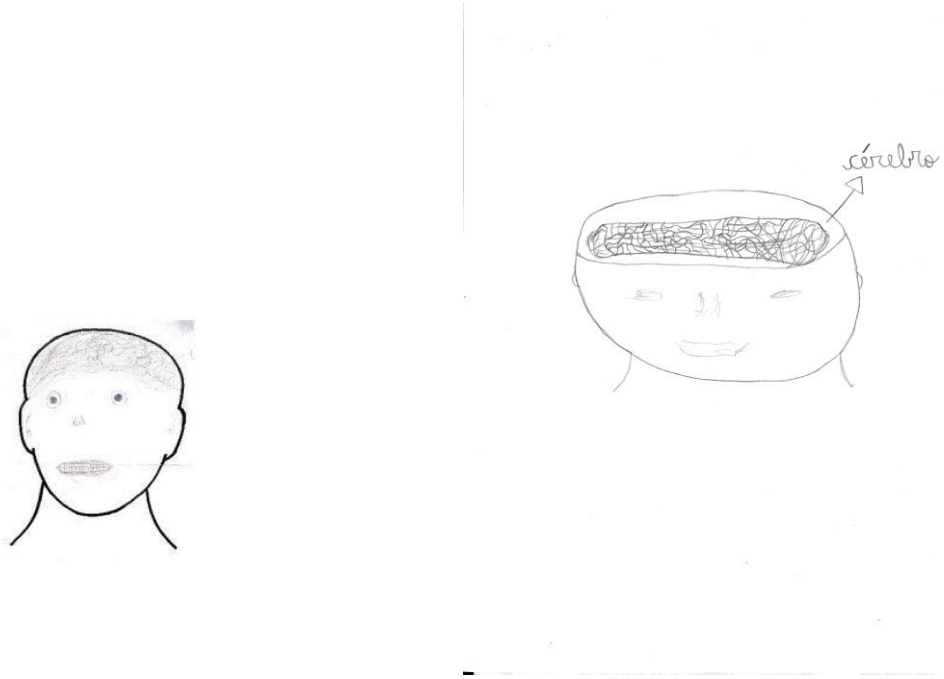

Figure 6 Examples of the drawings by 8–10-year-old children representing the skullcap model.

In total, there were only some drawings in accordance with the neuroanatomical model. They were done by the 8–10-year-old children (Figure 7).

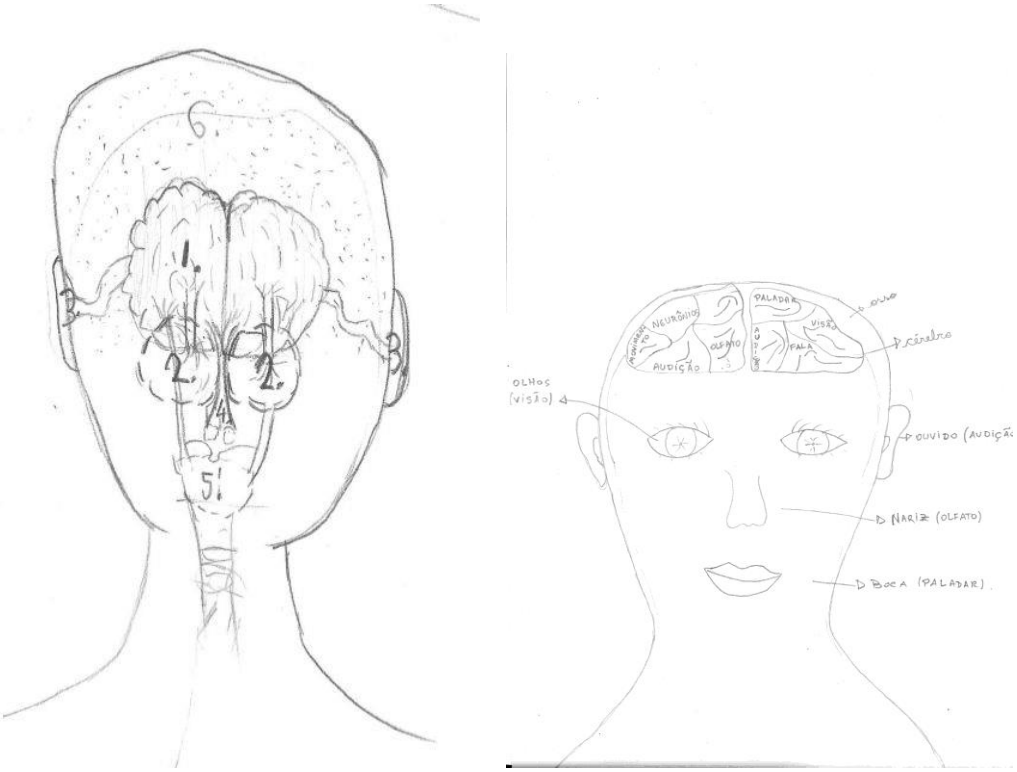

Figure 7 Examples of the drawings by 8–10-year-old children representing the neuroanatomical model.

Some of the Finnish children named parts of the brain such as cerebrum and cerebellum. A Finnish girl knew that the sense centre, the speech centre and the moving centre are located in

the brain. The children said that they got the information from television programme, a first-aid manual and their parents. During the interview it was appeared that the children did not understand exactly what they had heard and read (Eloranta, 2003, 243–244). The result supports the statement of Kronqvist and Pulkkinen's (2007, 137) that Finnish children in this age think by concrete way.

The anatomy and physiology of the brain are learned in the environmental studies during the grades 1–6 (Opetushallitus, 2014, 268). However, according to the Finnish children, human beings have many brains. The conception of many brains is based, maybe, on the Finnish name of the brain – aivot – what is a plural form. This is indicated by the observation that also the primary children, who had studied the brain just before our research, thought that human beings have many brains. They had either no clear conception of the structure of the brain. It seems that the children have difficulties to understand that the cerebrum, the cerebellum and the brain stem are the main parts of the brain and not different brains (cf. Langley et al., 1980, 226). The result supports the observation of Reiss et al. (2002, 58–63) that a child can have knowledge of different organs and parts of them but he/she does not understand the wholeness formed by them.

Conceptions of the function of the brain

From aged 5 the Finnish children located thought and after that also other functions into the head (Table 6). Most Finnish children aged 4–5 told that we need the brain when doing something required and thinking. The children aged 6–7 years also understood that we use the brain when we put something into memory and remember something. Most 8–10-year-old children also described the function of the brain using symbols. After aged 9 the children had knowledge that emotions originate in the brain. The result differs from the results of Gellert (1962). They also told about thought, remembering, and guiding of functions of the brain. They also told about composition and discussion. The older ones understood that we need the brain for living.

Table 6 Typical mentions of the Finnish children during the interview explaining their drawings and the role of the brain**.**

Age	Mentioned during the interview.
aged 4	The brain gives rules: you must be quiet.
aged 5	The brain thinks.
aged 6	The brain thinks, recalls, and commands.
aged 7	The brain says what is right and wrong.
aged 8	The brain includes ... such a picture machine. When I was a baby, I did not had it yet in my head but now I have it. And it gives me pictures; when I run it, it gives more slides. So, and it gives me….memories from some days.
aged 9	The brain tells you who you love.
aged 10	A human being can not live without the brain.

During interviews with the Brazilian children to explain their drawings and what the brain they think it does, the youngest pupils collectively mentioned ” *it is a place with pipes where blood and ideas circulate* ”, ”*where happiness lives*”, ” *a place with things that help us see, dream and sometimes aches*” (Table 7). Older pupils (8-10 year-old ones) which drew pictures resembling the brain structures said that ” *ideas are recorded and move in the inner lines and tubes*” ”*it feel pain* (head-ache!) ”, ”*gives will power and remember things*”, ”*make eyes, ears, arms and legs work*”, ”*control hunger and thirst*”, and ”*helps pay attention and think*”.

Table 7 Typical mentions of the Brazilian children during the interview explaining their drawings and the role of the brain.

Age	Mentioned during the interview.
aged 4	The brain makes us grow, calm down, think; the head protects the brain.
aged 5	The brain prevents that we get sick, have stomach ache, remember things, guess, think and dream.
aged 6	The brain is a group of tubes or vessels where the blood flows, is like ropes, makes us intelligent, happy, see, sleep, dream and we do not live without it.
aged 7	The brain helps us to pay attention when watching cartoons, learn and think, makes ideas circulate and how to write a letter to friends and relatives.
aged 8	The brain makes us have a will, learn anything we want if we work hard.
aged 9	The brain makes the body organs and organ systems to work properly, control our memory and help us remember and miss friends and relatives.
aged 10	The brain help us to deal with calculation such as sums and multiplications, to study lessons to sit for examinations, to say a poem!

So to sum up, most of the 4–10-year-old children knew that the brain locates in the head. Although they did not know the concept the brain exactly, they knew that the brain is needed for thought and functions of the body. Many children used mental images (Dunderfelt, 2011, 81–82) when describing the function of the brain. Mental images are related with the structuring of concepts (Vinner, 1991, 65–73) and the development of the schemata (Piaget, 1988, 159). Wadsworth (2004) suggests that schemata (the plural of schema) be thought of as 'index cards' filed in the brain, each one telling an individual how to react to incoming stimuli or information. The structure and function of the brain seem to be too abstract for most 4–10 year-old children. The result supports the observation of Bartoszeck and Bartoszeck (2012) that the younger children describe the brain generally through single functions instead the older ones use the neuroanatomy descriptions.

Conceptions of the blood vessels inside the head

Aged 4–5 Finnish children did not have conceptions of the blood vessels inside the head, only over 6-year-old children described them (Table 8). Some children did not know the concept blood vessel instead they used the word ”*tube*”. The older Finnish children had scientific knowledge of the functions of the blood vessels (Langley et al., 1980, 440).

Table 8 Typical mentions of the Finnish children during the interview explaining their drawings and the role of the blood vessels inside the head.

Age	Mentioned during the interview.
aged 6	The blood tubes transport blood.
aged 7	In the blue vessels blood runs in to the one direction and in the red vessels in to the other one.
aged 8	The function of the vessels is to keep a human being alive and give colour in to the skin.
aged 9	The blood vessels carry nutrients and oxygen to the muscles and structures like that.
aged 10	Blood cells move in vessels. There are such kind white cells what protect body.

Most conceptions, however, were shaky: ”*I do not know. I only remembered that there are blood vessels in the brain. So, I am not able to tell but some function they must have*.”. The children had many mistakes: ”*That ... from the brains the blood vessels go to the eyes, the nose and the*

ears." and: "*The blood vessels carry commands all around the head and all over the human body*." Some children used red and blue pencils for describing blood vessels. Although the children were not able to name the blood vessels they had pre-conception of the veins and the arteries (Langley et al., 1980, 440–459). The idea for colours based on books.

The Brazilian children did not have an idea that the blood circulates inside tubes in the brain but few children mentioned the existence of vessels in the brain. They used red colour pencils to indicate this idea but not more than this.

To sum up, after aged 7 the Finnish children knew that there are blood vessels in the head. Most conceptions were shaky and misconceptions were common. The Brazilian children follow the same trend as described on the Table 7.

Conceptions of the nerves inside the head

The Finnish children who draw nerves inside the head were from the primary school where a topic of human being was thought just before our research. The children told that their conceptions are based on the stories of their teacher. Some children remembered that they had heard of nerves but their conceptions were shaky: [My teacher] "*has told to me that nerves are able to do something and from them something comes into the brain. The nerves can do so that if someone touch you so it creates emotions*."

The Brazilian children seem not to be aware of nerves. They did not depict them on their drawings and did not mention the existence or function of nerves. Data was collected independent of previous discussion by teachers on how the brain works.

To sum up, it can be seen that some Finnish primary aged children had conceptions of nerves but the conceptions were shaky and included many misconceptions. Children mixed the functions of blood vessels and nerves with each other. All children who described nerves were from the primary school where the human topic was taught before our research. Teaching had effects on the conceptions of the children. However, even so the conceptions were shaky and mistakes common also after the learning period. The result resembles the observations of Bajd and Ivekovič (2010, 31–37). No data was collected from Brazilian children on this topic.

Conceptions of the eyes, ears, the nose and the mouth

About 50 % of the Finnish children aged 7–10 described external features such as the eyes, the ears, the nose and the mouth. Into the eyes some had written "*eyeball*" and they were not able to tell more about it. Some 7–10-year-old children had scientific knowledge. However, mostly the conceptions were incorrect and the children described their drawings like a girl: "*Voice tube* [goes] *into the mouth* [and it starts] *from the lungs*.". In her drawing, however, tubes went from the ears to the brain. Also in the drawings of some other children, there were tubes from the ears to the brain, from one ear to another, or from the brain to the eyes, the nose, and the mouth. The children told about their drawings for instance: "*That is an important part. It includes such kind flat part... if you touch it, it can be broken and then sense of hearing goes away. I know because I have been in doctor and it was put exhaust pipe.* ". The girl had knowledge about the eardrum between the outer and middle ear based on her experiences (Langley et al., 1980, 257). The exact knowledge of the structure of the eyes, ears, the nose and the mouth and the relation between them had no Finnish children. The descriptions were concrete what is typical during the concrete operational stage. A reason can also lay on the style how Finnish teachers and parents tell about phenomena and items to children.

The Brazilian children just mentioned the general functions of sense organs during the interviews but there was no detailed description presented on the drawings.

Some primary children used scientific concepts such as oesophagus, nasal cavity, ear canal, and

Eustachian tube. However, during the interviews it was noticed that they did not understand them. Knowledge is short and mistakes are common.

Other conceptions of the head

At the end of the interviews, the Finnish children could tell more about his/her drawing or other things concerning the content of the human head. A boy told that viruses affect symptoms: ”*Therefore I have headache because viruses have their own war in the head*.” Many children told about the muscles of the head, skull, nasal bone, jawbone, and ossicles. A child draw the whole skeleton inside the skull, and during his interview, he told that he did not have any knowledge that the skull belongs to the skeleton. Children also told stories what they had heard from their fathers but what they were not able to draw. A boy stated that ”*trombus is quite difficult to draw*.” and another boy that ”*My dad has told me about amazing leukocyte polices that they attack bugs.*” A boy described sepsis based on the animation series so: ”*If caries comes into a tooth and bacteria start to go into the brain…and they dig that hole and nest there. And when they go into a blood vessel then it comes through it and then it starts to go through and then comes sepsis and kills you.*”

The Brazilian children only describe what the brain does without dealing with other conceptions about the head.

To sum up, it can be seen that experiences of children affect their conceptions of the content of the head. The conceptions were shaky and included many mistakes. The result support the statement of Eloranta (2003, 238–248) that every-day experiences are important to take into account also in science education. No such every-day data was collected with the Brazilian children.

Discussion

The knowledge of the human anatomy and physiology is important. Through it we can understand effects of life habits on physical, mental, and social health and action (Andersson, 2008). It also helps us to understand that our selections affect environment (Palmberg & Svens, 2011). The crucial role in the development of understanding of children lays on teaching and learning processes. Teachers are able to support their students by meaningful way only if they know what their students know and think about learned issues. Many studies show that most 15-year-old children do not understand the human body as a wholeness (Reiss et al., 2002, 58–63). In this study, the conceptions of 4–10-year-old Finnish and Brazilian children of the content of the human head and the human brain are described. In addition, it will be discussed how the conceptions are related with scientific knowledge and how teachers can support their students to understand and learn biological information and concepts.

The conceptions of the 4–10-year-old Finnish children of the content of human head and the human brain were different and varied also within the same age group. Some children had every-day conceptions and some primitive scientific knowledge. The younger the children were, the stronger imagination dominated their conceptions. Most children knew that the brain is located in the head. Typically, the children described the brain through single structures. After aged 6 many children were able to list parts of the brain and tell that the brain are needed for thinking. Many children knew that the brain are connected with the eyes and ears and that they are needed in action. However, the concept the brain was not clear even for all 7–10-year-old children. Many of them thought that we have many brains. Also the function of the brain was unclear. The situation concerning the Brazilian children are similar. The results support those of Bartoszeck and Bartoszeck, (2012) that not until aged about 10 children are able to observe items and

phenomena realistically. No one of the children was able to tell how the brain parts act and what kind wholeness they form as they are very young and thus more elementary neurophysiology practical classes are in demand (Rushton et al., 2010). Johnson and Wellman (1982, 223) have also stated that children understand first the brain as a thinking organ and later on that the brain regulates all action of the human beings. That children are able to understand the organ systems as a wholeness teaching should be started from single organs and go step by step towards the wholeness of body (Reiss et al., 2002).

The external and palpating structures are understanable by children and they form important part of their living environment. The content of what is inside the head is difficult to understand because its function is an abstract thing. The conceptions of the children were shaky and included many misconceptions. Although many primary children used scientific concepts of the content of the head their knowledge of its structure and function was limited. For instance they mixed the blood vessels with the nerves. The result support the view of Vygotsky (1982) that a child recognizes a scientific concept better than the object of it. It was observed that also the 8–10-year-old children understand scientific concepts by the concrete way. Consequently in teaching and learning situations, it is not enough if a child tell what he/she knows about the learning issue, instead a teacher should clarify what a child means with the concept used by him/her. If misconceptions are not corrected during primary education, they can hinder learning of scientific information later on.

Social experiences and family culture affect the conceptions of children (Latomaa, 2000). Children at the same development stage have different conceptions of the content of the head. Although some children had primitive scientific knowledge most conceptions included informal information based on every-day experiences of children (cf. Havu-Nuutisen, 2005). Many children described the content of the head and the brain using concrete acts and argued that their teachers or parents had told so or that they had seen it on television. According to Jarasto and Sinervo (1997, 98–99) the concepts used by a child are not always scientific but they are useful in the meaning of a child. Knowledge of a student and understanding of his/her experiences and every-day conceptions are important for teachers because they can affect the structuring of their students' scientific conceptions only if teaching is in concordance with the cognitive development stage of a child.

Teaching has effects on the conceptions of the learning thing and phenomena (Vygotsky, 1982, 169; Bajd & Ivekovič, 2010). The drawings made by the children who had studied human body before our research, included less external features than other drawings. These drawings were more realistic and they were not based on pure imagination. The children from this group draw also nerves inside the head. Beside student knowledge also subject knowledge is important for teachers to know. It includes content knowledge and teaching knowledge. (Shulman, 1987.) Through content knowledge a teacher can recognize mistakes and deficiencies in the conceptions of a child and through teaching knowledge he/she can select objectives, methods, learning material, learning tasks, and learning environment supporting learning of a child. According to previous studies it has no meaning if a curriculum and teaching processes are structured based on the either traditional, subject-based knowledge or modern integrative, interdisciplinary knowledge (Åström, 2007). Instead learning is affected interest, attitudes, and motivation of a student (Duit & Treagust, 2003). These are affected information as such (Helldén, Lindahl, & Redfors, 2005), joy of learning, and experiences of succession (Osborne, Simon & Collins, 2003). Also learning environment and teaching methods are important (Echinger, 1997; Smeds et al., 2015).

In the Finnish curriculum for basic education (Opetushallitus, 2014, 2015), teachers are

encouraged to use different learning environments and various teaching and learning methods. Authentic teaching and learning situations (Smeds et al., 2015) and problem-based methods (Yli-Panula, 2005) support learning of abstract things (cf. Ahopelto, Mikkilä-Erdman, Penttinen, & Anto, 2009). Learning is effective when activities are based on different senses (Szczepanski & Dahlgren, 1997; Tauriainen, Jeronen, Lindh, & Kaikkonen, 2013). E.g. mistakes concerning agriculture were decreased when teaching was carried out in farms (Smeds et al., 2015). When learning situations are integrated with things and actions what are important for students, students understand better what they should learn and remember longer what they have learned (Krogh & Jolly, 2012).

According to educational books, the anatomy and physiology of the human body can be taught using e.g. experiential methods such as problem based learning, project learning, group work, and mind and concept maps. Also laboratory work and demonstrations are good ways to concretize structure and function of the human body. Visits to research institutes and researchers' visits at schools add authenticity. Plays and information and communication technology bring liveliness to learning situations. (Eloranta, Jeronen, & Palmberg, 2005, 97–158.) Discussions and co-operative learning support the structuring of conceptions (Gelman ym., 2010). However, more investigation is needed about how different teaching and learning methods and environments really affect childrens' structuring and understanding of biological concepts.

According to Bajd and Ivekovič (2010, 31–37) activities support understanding of the human anatomy and physiology. It is possible that kindergarten and primary aged children can make small studies about their body. E.g. they can palpate bones and muscles, examine size, form and relations of different organs using lay figures and organ models. They can also search information about functions of human body from internet and libraries and discuss about the factors affecting health based on their findings. A teacher has a crucial role as a motivator and a guide in these kinds pupil-centered learning methods (Vauras, Kinnunen, Kajamies, & Lehtinen, 2013). Some children are curious to experience and to learn new things, others are timid based on their temperament. However, learning skills and level are not depending on temperament. Through education, support and experiences also a timid child learns to thrust him/herself and act goal-directly in new situations (Keltikangas-Järvinen, 2004).

The development of scientific literacy is important to take into account when selecting learning material. The term scientific literacy refers to a skill to acquire new knowledge, an understanding of key scientific terms and concepts (i.e., science content knowledge) as a form of human knowledge; as an awareness and understanding of the impact of science and technology on society, and willingness to engage to act as a reflective citizen (Miller, 1983; Organization for Economic Cooperation and Development, 2009). As learning material, media will be more important in future also in biology education. The creation and study of material is a big task for teacher educators and teachers In Finland because Finnish material of human body what is suitable for kindergarten and primary education concerning the human body does not exists yet and it is also scarce in Brazil.

In qualitative research, reliability can be thought of as the trustworthiness of the procedures and data generated (Stiles, 1993). It is concerned with the extent to which the results of a study or a measure are repeatable. The research methods and results are described thoroughly. Quotes from the childrens' expressions describing the children's conceptions are reported for trustworthiness (Miles & Huberman, 1994). In the phenomenographic research, validity of the research is depending on credibility (Eskola & Suoranta, 2008, 212).The findings are confirmed by revisiting data in different circumstances (Bryman, 2001). Because we were personally familiar with the kindergartens and schools participated in the study, we minimized bias in the data

collection, interpretation and presentation of the findings by using 'bracketing', whereby we continuously reflected openly on our own ability, our experience, judgement and beliefs (Cutcliffe & McKenna, 1999). We used also another way of enhancing the validity of our study, triangulation. We gathered material at different kindergartens and schools in two countries, in Finland and in Brazil, and our material included the drawings and the interviews of the children based on their drawings (Halcomb & Andrew, 2005; Williamson, 2005).

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