DIPLOMARBEIT

Titel der Diplomarbeit

Application of System Thinking Skills by 11th Grade Students in Relation to Age, Gender, Type of Gymnasium, Fluently Spoken Languages and International Peer Contact

Julia Rose

angestrebter akademischer Grad

Magistra der Naturwissenschaften (Mag.rer.nat.)

Wien, 2012

Studienkennzahl lt. Studienblatt:	A 442
Studienrichtung lt. Studienblatt:	Diplomstudium Anthropologie
Betreuer:	Ao. Univ. -Prof. Dr. Harald Wilfing

With thanks to Ao. Univ. -Prof. Dr. Harald Wilfing and Mag. Dr. Karen Kastenhofer

Table of Contents

1. Introduction

1.1 Relevance of System Thinking

"We tend to blame outside circumstances for our problems. 'Someone else' – the competitors, the press, the changing mood of the marketplace, the government – did it to us. Systems thinking shows us that there is no outside; that you and the cause of your problems are part of a single system." (Senge, 1990: 67)

Throughout history, we have proven ourselves eager to look for singular causes for all significant happenings in our lives, from miracles to catastrophes. The ups and downs of our personal experiences are often considered fate or the will of a higher entity. We are prone to praising an idol or seeking a scapegoat to explain fluctuations within society, and in the sciences we are tempted to quest for the one key factor that causes or resolves a pressing problem. Although our world is not any more complex today than in past centuries, it is only in recent decades that we have been confronted by global challenges such as global economy, security, and health as well as climate change and unprecedented demographic transitions. In face of such highly complex phenomena, we might find ourselves more competent in action if we expand our understanding of the phrase "everything happens for a reason" to "everything happens for many reasons".

It has become increasingly apparent how the understanding of systemic connections is vital to our success in the fields of technology, in the sciences, in politics and management and even in society. Viewing a system as a whole can help us better understand developments and reactions of our environment and the consequences of our own behavior (Sommer, 2005). If we want to move toward a sustainable future, we need to become more aware of the reactions we cause within the systems that we are a part of. But in order to do that, we need to be accustomed to system thinking.

Former Secretary General for the United Nations, Maurice Strong, stated in 2001 that "a crucial ingredient for sustainable development is a well-informed public. All actions that impact the environment come ultimately from individuals." (Strong, 2001: xiii) However, "most people are concerned about the environment but feel overwhelmed by the complexity and scale of the problems." For this cause, system thinking is becoming an increasingly important approach in the attempt to better understand the developments in our environment.

Not only do systems affect us on a global scale, but we can find them all around us every day. In his dissertation presented to the graduate school of the University of Florida in 2006, Richard Plate emphasizes that systems "affect every aspect of our lives, from our social and economic endeavors down to the food we eat and the air we breathe." (Plate, 2006: 13) He believes that the key to a better understanding lies in the structure of the currently conventional curriculum. Plate writes "our problem is not that we do a poor job of teaching our students to deal with complexity; it is that we do not even attempt to address complexity." (Plate, 2006: 71) In his view, we are inclined to ignore complexity due to its inconvenient and confusing nature, only to be surprised and frustrated by the results of the behavior of the complex system.

The cognition psychologist Thomas Lecher also refers to the disregard of the complexity of systems when he criticizes the current research of our environmental awareness. He believes that so far, this awareness is measured primarily by knowledge on certain subjects and verbally expressed behavior, but neglects the complexity of the networks between economy and nature. Yet if we only measure the extent of expertise of individuals, we won't be able to fully capture the environmental awareness, for many conflicts arise in the incompatibility between economic and ecologic processes (Lecher, 1997). Again it appears to be the complexity of systems that we appear unable or unwilling to cope with.

Why is it that we seem to be so unprepared to face the complexity of the problems that we are confronted with on a daily basis? A possible answer can be found in the approach we have been taught in childhood to solve the problems we encounter in life.

At a major symposium of the World Summit on Sustainable Development in 2002, UNESCO Director-General Koïchiro Matsuura outlined a new vision for education for sustainable development. "Education – in all its forms and at all levels – is not only an end in itself but is also one of the most powerful instruments we have for bringing about the changes required to achieve sustainable development." He further stated that "this new vision of education emphasizes a holistic, interdisciplinary approach to developing the knowledge and skills needed for a sustainable future." (United Nations, 2002)

This of course begs the question to what extent does our current educational system offer a holistic approach? Moreover, to what extend does it cultivate system thinking?

1.2 Curriculum Conflict?

Frank Betts, Director of the Curriculum/Technology Resource Center at ASCD (Association for Supervision and Curriculum Development), explains in his book *Improving School Quality* why the current public education system is failing (Betts, 1992). He states if we look into the past, we can see that from its inception onwards, public education has aimed to transmit core knowledge and cultural values to prepare students for their later life with critical and creative thinking to aid their decisions and problem solving skills. Though it was successful in transmitting knowledge, it has been much less successful in preparing children for life after school. "Public education's overwhelming success as a pattern maintenance institution is at the heart of its failure to match changing societal expectations." (Betts, 1992: 38)

He believes our efforts to make a transition to a more effective educational program have met with so little success due to *paradigm paralysis*, which he defines as "the attempt to interpret current experience using old models and metaphors that are no longer appropriate or useful." (Betts, 1992: 38) With this in mind, he states that a new paradigm is needed, one that would be better suited by illuminating the whole instead of just parts, one that is synthetic in favor of analytic, and that rather integrates than differentiates. Moving away from conventional reductionist education programs, he believes this new paradigm is systems thinking.

Professor Emeritus and Senior Lecturer of the Sloan School of Management Jay. W. Forrester outlines the problem that many conventional school systems are faced with (1992). By compartmentalization, subjects like social studies, physical science and biology are separated and taught as if they do not share the same underlying concepts, and the interactions of these subjects in the real world are neglected. He believes the time dimension should be more directly treated by education, with questions like "What causes change from the past to the present and the present to the future?" To him, conventional educational programs rarely provide answers to how things change through time, as the key lies in dynamic behavior of systems.

"Education has taught static snapshots of the real world. But the world's problems are dynamic." (Forrester, 1992: 6) Although he believes that the human mind and intuition is ill-equipped to simulate dynamic behavior of systems with interacting components that change over time, he is certain that dynamic behavior of systems can be taught and understood by students. Though a simple social system might require a tenth-order, highly non-linear differential equation to be represented, Forrester feels certain that even a junior-high school student can be coached into understanding such systems with the aid of computer simulation.

Nevertheless, Forrester points out that the systems approach might turn out ineffective if the educational setting remains traditional and the students passively receive lectures without hands-on involvement, which he sees essential for internalizing ideas and creating own mental models when learning (1992).

Concurring with Forrester's train of thought, Debra A. Lyneis and Davida Fox-Melanson of Carlisle Public Schools presented their findings at the International System Dynamics Society Conference in July 2001. They believe that the reach of system dynamics in education has the potential to go beyond individual learning of the students. "It promises to transform the structure of education itself." (Lyneis & Fox-Melanson, 2001: 1) They have found that with the help of a system dynamics perspective, teachers can take on the role of guides in helping students engage themselves in working together to use the new tools of system dynamics and construct their own knowledge. No longer would teachers be dispensing information that is passively received by the students in a conventional lesson, but students learn how to figure things out for themselves.

In a more recent paper, Forrester furthermore emphasizes the need for students throughout their K-12 education[1] to be repeatedly confronted with computer modeling (Forrester, 2009). He sees modeling as a tool to help resolve debates and misunderstandings, and he has seen differences of opinions converge into agreement once the unexpected behavior of a model becomes understood. Though he doesn't assume every student will need to construct models in later life, he points out that computer models will be employed more frequently as a basis for determining social and economic policies and feels 21st century citizens should be able to read, understand and evaluate these models in order to properly participate in the decision making process.

Concerning the current common educational program, Plate states he does not see need for a radical departure from a conventional curriculum (2006). He feels it is not the course subjects and content that require much change, but the approach to the content and the connections drawn between the subjects. For example, he suggests "the same tools and concepts used to understand the motivations for a character in a novel read in English class can also be applied to understanding political dynamics in a social studies class." (Plate, 2006: 65) Nevertheless, he points out that this does not mean a system-oriented curriculum can provide a complete understanding of either the novel character or the political motivations mentioned in the example. It simply offers insight into a system and the general concepts can help students transfer their knowledge more easily than if they had to identify general rules based on facts on their own.

Though system thinking allows focus on interconnections and lets you see the common elements in settings rather than the differences, one must bear in mind that it shouldn't be used as the sole and universal approach (Plate, 2006). Forrester however points out that since science, economics and human behavior rest on the same kinds of dynamic structures, an understanding of these systems can create a common language (2009). He sees a reversal of the specialization trend in the future back to what he calls the concept of the "Renaissance Man", a person whose broad intellectual interests and accomplishments unite the different fields.

[1] Kindergarten through twelfth grade.

2. System Thinking in Current Research

2.1 Defining System Thinking

The term “system” comes from a Greek word *σύστημα* meaning “whole compounded of several parts or members”, or in the literary sense “composition”. It can be defined as “a set of interacting or interdependent system components forming an integrated whole.” (Lidell & Scott, 1940)

All disciplines dealing with systems, be it social, technological or natural, have their own approach to the understanding of the term “system”. “The architecture of systems theory becomes apparent in the description of the theory if one treats it as a system in itself. Systems have their own environments, and the environments surrounding systems theory consist of other theories. These constitute the nutrient solution that feeds the organism we call ‘systems theory.’” (Schwanitz, 1995: 139)

There are many different system theories that range from the general systems theory of Ludwig von Bertalanffy to the sociological systems theory of Niklas Luhmann and synergetics of Hermann Haken. Since each discipline seems to have their specific definition of what makes a “system”, how can we keep an overview?

In the following chapter I present a brief outline of several prominent system thinkers and their broad variety of fields and schools of thought they represent. This list is of course not complete, and many more could be included.

2.1.1 Prominent System Thinkers and Schools of Thought

Ludwig von Bertalanffy

“There exist models, principles and laws that apply to generalized systems or their subclasses, irrespective of their particular kind, the nature of the component elements, and the relations or “forces” between them. It seems legitimate to ask for a theory, not of systems of a more or less special kind, but of universal principles applying to systems in general.” (Bertalanffy, 1968: 32).

Ludwig von Bertalanffy was a 20th century scientist who played a prominent role in the paradigm shift from an analytical approach of breaking systems down into their components for a better understanding to viewing systems as a whole. He formed the General Systems Theory in 1928 characterized by nonlinear interactions of the components of a system, but he didn’t publicize his theory until after the Second World War (Walonick, 1993). In the sixties, he defined aims for his general systems theory:

“(1) There is a general tendency toward integration in the various sciences, natural and social.
(2) Such integration seems to be centered in a general theory of systems.
(3) Such theory may be an important means for aiming at exact theory in the nonphysical fields of science.
(4) Developing unifying principles running “vertically” through the universe of the individual sciences, this theory brings us nearer the goal of the unity of science.
(5) This can lead to a much-needed integration in scientific education.”
(Bertalanffy, 1968: 38)

Niklas Luhmann

Another prominent 20th century thinker was Niklas Luhmann, who applied the theory of autopoiesis that Francisco Varela and Humberto Maturana had developed to social systems. His works are abstract, so I will refer to Dietrich Schwanitz’s analysis of Luhmann’s System Theory. Notable about Luhmann’s theory is a duality in its construction, stemming from the fact that he had developed his system theory in two phases. First he worked on “systems differentiation”, for which he had let himself be inspired by Bertalanffy’s general systems theory. It focuses on the system’s architecture rather than the elements and internal differentiation is found only within same types of systems. In 1984, Luhmann published *Soziale Systeme* including the concept of autopoiesis (Schwanitz, 1995).

“To use an analogy, systems differentiation corresponds to the floor plan of a house with its division into bathroom, hall, bedroom, drawing room, kitchen, etc., whereas in autopoiesis we are concerned with the construction of the house from bricks, timber, mortar, and beams.” (Schwanitz, 1995:147) In other words, the first instance is about the combination of elements while the second deals with their composition. Luhmann was faced with the problem of what elements would make it possible for social and psychic systems to comprise themselves by having their underlying processes refer to them, and came to the pivotal conclusion to add the dimension of time. With this came the idea that the constituting elements of social and psychic systems are events (Schwanitz, 1995).

Hermann Haken

In 1969, Hermann Haken founded an interdisciplinary field of research known as synergetics, which focuses on material or immaterial systems and is characterized by a strong interplay of experiment and theory. Spontaneous, often self-organized emergences of new qualities are the central focus of this field. Such emergences can take the form of structures, processes or functions. Furthermore, synergetics tries to find general principles for the self-organization of emergences regardless of the constitution of a system’s individual elements (Haken, 2007).

When taking qualitative changes on macroscopic scales into consideration, general principles can indeed be found for many types of systems despite the broad variety in nature of individual parts, which can consist of anything from atoms to human individuals in society. The macroscopic scales would have to be a choice of spatial and temporal scales that in comparison to the individual parts of the system are of large size. Interactions can take place on different levels, such as between elements, between systems or in a transdisciplinary sense between different fields of science. This leads back to the root of the word “synergetics”, which in Greek means “working together” (Haken, 2007).

Kenneth E. Boulding

Kenneth E. Boulding is known along with Ludwig von Bertalanffy to be a founding father of the general systems theory. In 1956, he developed a classification of systems as shown in Table 2.1:

Table 2.1

Level	**Characteristics**	**Example**
1. Structures	Static	Bridges
2. Clock works	Predetermined motion	Solar system
3. Controls	Closed loop control	Thermostat
4. Open	Self-maintaining	Biological cells
5. Lower organisms	Growth, reproduction	Plants
6. Animals	Brain, learning	Birds
7. Man	Knowledge, symbolism	Humans
8. Social	Communication, value	Families
9. Transcendental	Unknowables	God

He is also considered to be the founder of evolutionary economics, as he opposed the at the time widespread mechanistic view of economics. Instead, he brought forth a theory in which time is asymmetric and economic processes are globally irreversible. Economy itself is set within an extensive system-wide ecological framework. (Dopfer, 1994)

Anatol Rapoport

Another prominent system thinker is Anatol Rapoport, who is known for his work on moral conflict, in particular individual and international conflict resolution in light of the Game Theory (Sheatsley, 1996). He has furthermore contributed greatly to the fields of mathematical psychology, mathematical theories of social interaction, general systems theory, probabilistic theory of graphs and networks, game theory, and semantics. One of his most prominent characteristics is his combination of philosophy and science, as he unites a deep humanistic commitment to profound system thinking (Schwaninger, 1998).

Rapoport emphasized the analogy to physics in systems research, as each system has a set of physical limits. His most important contribution to the system science was in Game Theory, in particular the Prisoner's Dilemma, in which two prisoners must make a choice on whether or not it would pay off to betray their accomplice in hope of a reduced sentence (Rapoport, 1965). The scenario he created can be applied to other situations as well, such as the arms race and market competition.

As Rapoport set his game theoretical studies in a systemic framework, he became more involved in the field of ecology and peace research and founded the initiative Science for Peace. The most prominent issue his work revolves around is aggression and confrontation of superpowers on a global scale (Schwaninger, 1998). To combat manipulation of persons, violence, exploitation and corruption he uses a systemic holistic base to form his arguments and creatively pioneered dimensions of rationality in his theoretical models to improve the quality of life, peace, and the survival of humanity by using innovative systemic strategies for conflict and cooperation.

Gregory Bateson

System thinking made its way into the social and behavioral sciences in the 1940s, promoted by Gregory Bateson (IIS, 2011). In 1972, he further influenced these fields by applying cybernetics to ecological anthropology with his book Steps to an Ecology of mind. In his view, the world consists of many systems that are characterized by competition and dependency between each other. Their balance is controlled by feedback loops that help them adapt by changing multiple variables, therefore correcting themselves conservatively. Systems can consist of individuals, societies and ecosystems, all of them in constant interaction with one another (Bateson, 1972). He considered this concept of homeostasis the key to maintaining natural ecological systems.

For Bateson, these systems combined were part of a supreme cybernetic system with control over everything, which he referred to as Mind, and can be compared to an entity such as God. He furthermore believed that human attempts to rule over the cybernetic systems and the changes to the environment that follow is in conflict with the supreme system, and causes unbalance in competition and dependency. Eventually the entire system would collapse, as humans would never be able to control all systems and they would cause more damage to the supreme system than the self-correcting process is able to repair. In the end, humans could be trapped in the new system they created (Bateson, 1972).

Donald T. Campbell

A strong proponent of a system of omniscience, Donald T. Campbell introduced the Fish-Scale Model as a way for scholars to connect their various disciplines (Campbell, 1969). He believed that research was only being conducted in largely overlapping fields, leading to an ethnocentric character of science and knowledge and leaving gaps between the different disciplines. “The disciplinary clusters may at their edges overlap other clusters, but as ships that pass in the night, they fail to make contact.” (Campbell, 1969: 328)

Therefore Campbell proposed the Fish-Scale model, in which no two scholars cover the same kind of field and their areas of specialization overlap like the scales of a fish instead of like towers of round coasters. This way, all knowledge would be networked without interdisciplinary gaps and this would in turn lead to an omniscience void of redundancy.

“Rather than praying, ‘May I be a competent and well-read X-ologist, may I keep up with the literature in my field,’ a scholar will pray, ‘Make me a novel fish-scale. Let my pattern of inevitably incomplete competence cover areas neglected by others.’” (Campbell, 1969: 340)

Jay Forrester

As the founder of system dynamics, Jay Forrester defines system thinking as only the talk about systems without simulation or an experimental approach. He warns that this superficial approach can be counterproductive, especially when expecting intuition to yield effective results (Forrester, 2010). In comparison, system dynamics focuses on the complexity of systems and emphasize the importance of temporal changes. It takes an experimental approach through computer simulation of real-life situations with the help of feedback control to observe the behavior of the system under various influences. To him, system dynamics is the foundation on which system thinking is based on, and entails the necessary depth to navigate the complexity of systems.

Forrester was not only a pioneer in system dynamics, but also in the introduction of system dynamics in pre-college education, shaping the way course material is taught and discussed in schools that are introduced to his concepts. Already in kindergarten children learn about basic principles of systems, and in middle school they manipulate simple computer models (Forrester, 2010).

Peter Checkland

Peter Checkland is the founder of soft systems methodology based on the methodology of system thinking, which came about when he researched a way to approach wicked problems that are ill-defined or not easily quantified. Soft systems methodology consists of a process of inquiry into complex problems, which is created as a learning system using models (LUMS, lums.lancs.ac.uk).

The rise of soft systems methodology led to a paradigm shift away from hard system thinking, which treats problems as well-defined with an optimum solution and the system itself as a physical entity. In soft systems methodology, the system itself is epistemological, open to different viewpoints and serving as a frame for our understanding of a situation (Checkland, 1981). Peter Checkland explained the difference between hard and soft system thinking as following:

“Hard systems thinkers view systems like a bag of marbles; you can put your hand in the bag, remove a marble, examine it, replace it and all is well. Soft systems thinkers view systems like a privet hedge; if you try to pull out a branch, you will strip off its leaves and twigs, damage the hedge in the process, and it is not replaceable.”

Donella Meadows

The most famous and influential of Meadows’ works was *Limits to Growth*, of which she was lead author in 1972. It discussed Earth’s limit of resources in context to unchecked economic and population growth, using the help of computer modeling. For sixteen years she furthermore wrote *The Global Citizen*, a weekly syndicated column on world events as seen through the eyes of a system thinker, examining the systems that create the complex problems that society was and is faced with (DMI, www.donellameadows.org). Nevertheless, Donella Meadows explained that system thinking does not necessarily give you a better viewpoint, just a different one. “Like any viewpoint, like the top of any hill you climb, it lets you see some things you would never have noticed from any other place, and it blocks the view of other things.” (Meadows 1972: 2)

Meadows originally stemmed from the school of system dynamics, and she admitted her use of language and symbols relate to that field (Meadows, 2008). To her, it is due to human personality that many different schools of thought on systems thinking cropped up, despite the overarching concepts they all encompass. She considered herself to present the core of system thinking as opposed to abstract theory, for she was interested in maintaining a connection to solving problems in the real world. She believed system thinking not only transcends culture and disciplines, but also history, and therefore systems jargon is reflected in traditional wisdom. An example she gives is the trouble that can be caused by feedback delays in complex systems in comparison to the message of the old wisdom “*A stitch in time saves nine*.”

2.1.2 Classifications of System Thinking

Frank Betts (1992) feels like the call for systemic change in education is becoming more and more urgent, yet the word “system” has suffered a popularization. Everything is considered a system yet nothing is treated as one, and he believes the fundamental implications need to be understood before one can say they are using a systems approach. He sees unsuited models and metaphors be used for popular interpretations of systems and therefore the terminology should be defined more precisely.

Frank Betts explains the concept of systems thinking with a simple metaphor. “Even a small child can use a hammer and saw, but it takes a master carpenter who fully understands the tools and their limitations to build a house.” (Betts, 1992: 38) He defines a system as a set of elements that together achieve a common purpose, where each element is defined as a necessary but not self-sufficient component. Without every single element, the system cannot achieve its purpose, and the isolated element cannot function the same as when embedded within the system.

Betts furthermore attributes synergy to a system, saying the sum of elements is always less than the system as a whole, because the relationships between the elements also add value. Due to the relationships between the elements, new properties emerge that determine the behavior of the system (Plate, 2006). These properties do not exist in the isolated elements, so that our understanding would move from a causal chain to that of a causal web, as Plate explains. Nonlinear causality characterizes the systems theory. Feedback loops between elements provide stability for the system. Ackoff emphasizes the extent of a system thinking approach: “System is more than just a concept. It is an intellectual way of life, a worldview, a concept of the nature of reality and how to investigate it” (Ackoff, 1999: 1).

Plate (2006) further compares a systems approach to that of reductionism in the line of Isaac Newton and Rene Descartes. Reductionism is characterized by understanding through studying a body’s component parts. To study these parts, they are taken apart into their components, until the smallest possible elements remain. For some problems, this kind of approach is well suited, for example in anatomy or mechanics. For problems involving social networks or ecosystems, a reductionist approach is likely to fail to provide satisfying results. Though both concepts are useful, neither contains the answer to everything. In Plate's own words: "Proponents of systems theory do not deny the utility of reductive analysis; they simply deny its primacy." (Plate, 2006: 50)

Therefore, Evagorou et al. (2008) feel one can expect a system thinker to be able to perform several tasks essential to implementing the theory. They need to be able to analyze interrelationships between objects and should be able to explore emergent properties. They need to be able to analyze problems in wider contexts and keep multiple cause-and-effect relationships in mind. A system thinker should be able to understand the dynamic processes of delays, feedback loops and oscillations that characterize a system. Long-term consequences and effects of present actions on future developments as well as changes in a system over time should all be considered, anticipated and understood by someone employing a systems approach.

Sommer (2005) summarizes the different types of systems according to their properties. One can differentiate between closed and open systems, complex and simple systems, and dynamic versus static systems. She categorizes the research field of systems thinking into five main approaches:

- **Qualitative**, like in the case of Vester's bio-cybernetics approach in 1988 and system-oriented management approaches of Gomez and Probst in 1987
- **System-dynamic**, like in the quantitative modeling of systemic connections with specialized software by Forrester in 1969
- **Complex problem solving** as Dörner applied in 1989 in research of behavior in complex computer simulated scenarios, and Putz-Osterloh in 1987
- **Ecological thinking** of Lecher in 1997
- **Systemic thinking** according to Ossimitz in 2000.

The purpose of a system can also serve as categorization criteria. Ackoff's (1998: 30) classification of four systems can be determined by the hierarchical purpose of each:

- Deterministic: "*neither the parts nor the whole are purposeful*", like in a computer.
- Animated: "*the whole is purposeful but the parts are not*", for example a person.
- Social: "*both the parts and the whole are purposeful*", for example a community
- Ecological: For example a wetland where "*some parts are purposeful, but not the whole*."

A framework was adopted by Hmelo, Holton and Kolodner (2000) and Hmelo-Silver and Pfeffer (2004) to explain complex systems, Structure – Behavior – Function (SBF). Physical structures are tied together by their behavior to carry out a system's function, which refers to the dynamic mechanisms allowing structures to fulfill a purpose of the system.

It is also possible to classify system thinking skills on a hierarchical scale, ranked by the difficulty of acquiring a skill. In the *International Journal of Science Education*, a classification system by Assaraf and Orion (2005: 556) is presented in following four levels:

1. Ability to identify a system's components and processes
2. Ability to identify relationships between separate components and the ability to identify dynamic relationships between them
3. Ability to understand the cyclic nature of systems, to organize components and place them within a network of relationships, to make generalizations
4. Ability to understand the hidden components of a system and a system's evolution in time.

With this hierarchy, Assaraf and Orion saw a possibility for applying this in education by having the lower level skills serve as a basis for developing the higher levels.

2.2 System Thinking in Context of This Study

The approach to system thinking in his study will support itself on the literature review of Assaraf and Orion (2005), which results in eight emergent characteristics of system thinking and the research tools adjusted to characterize the eight mentioned system thinking skills. Although each discipline has their own way of approaching a system, these eight characteristics are commonly shared.

They identify (2005: 523):

1. *"The ability to identify the components of a system and processes within the system*:" In relation to this study it means the correct application of elements and processes.

2. *"The ability to identify relationships among the system's components*:" For the "stress of a student" system used in this study, this could be for example the acknowledgement of connection between exams and grades.

3. *"The ability to identify dynamic relationships within the system*:" In this study, dynamic relationships can be expressed in the connections of elements. Dynamic relationships differ from static relationships in their mutability.

4. *"The ability to organize the system's components and processes within a framework of relationships*:" This will present itself in the constellation of elements and connections (e.g. chain, circle, network).

5. *"The ability to understand the cyclic nature of systems*:" Understanding the idea that we live in a cycling world with sub-cycles.

6. *"Understanding the hidden dimensions of the system*:" Recognizing patterns and interrelationships which are not seen on the surface, for example that stress can have a negative impact on health and well-being.

7. *"The ability to make generalizations:"* This can be expressed by the student assessing if their created concept map is case-specific or general.

8. *"Thinking temporally: retrospection and prediction*:" Understanding that the system's interactions are influenced by the past and will result in future events that can be attempted to predict.

These system thinking skills will be used in this study to assess the extent of the ability of students in the sample to think in systems, as further discussed in Data Analysis on page 35.

2.3 Research of System Thinking Skills of Students

Throughout many schools, today's approach to education is still strikingly similar to the 19th century, as a study from O'Hara and O'Hara revealed (1998). In traditional education, a teacher stands in front of the classroom for the majority of the time and lectures while students take notes. Students are encouraged to work individually, directed by the teacher. According to O'Hara and O'Hara's experience, memorization and regurgitation are the most common methods used by students to learn new concepts, which are easily forgotten. Problems are mostly solved by linear thought processes and step-by-step instructions are desired by students.

As the world outside the classroom is rapidly changing, traditional methods struggle to engage students in lessons about the environment (O'Hara & O'Hara, 1998). In 1997, Steinberg found that teachers spend around 80% of their time lecturing. He also discovered that most of the students' time was taken up by individual seatwork, listening and studying. The question arises, how successful are schools today in promoting a system thinking approach to prepare students for the complex problems that they will be confronted with in life?

It can be argued that children are natural system thinkers that can understand one-way causality from the age of five months, for example when crying causes their parents to pick them up (Booth Sweeney, 2001). In 2005, Sommer studied elementary school children to assess their system competence. The children were able to apply system thinking on a basic level and they succeeded in creating concept maps, increasing systemic representation mediums. Nevertheless, people tend to prefer simple, causal explanations to the complex connectedness of system thinking when trying to understand a complex phenomenon (Jacobson, 2001).

In early studies with high school students it was revealed that the students are able to develop system thinking skills to solve complex problems, but they easily reverted back to the more simple solutions (Resnick, 1996). Research on middle school students indicates that most of the students struggle with all characteristics of system thinking, no matter how basic. The more actively involved the students were in the learning process however, the better their system thinking skills were developed, although not all students were able to reach the highest level (Assaraf & Orion, 2005). Even university students often resort to simple approaches when attempting to solve complex system problems (Jacobson & Wilensky, 2006).

A research project conducted by Günther Ossimitz on system thinking and representation medium competence revealed that teachers play a key role in the performance of students. About 130 students between the ages of 14 and 18 years were studied and no connection could be found between the performance and age, gender, grade in mathematics, previous computer experience or regional environment (Ossimitz, 2000). Another study confirms the external influence of teachers on students, where teaching staff and lessons were more closely analyzed as part of the project System Earth (Hlawatsch et al, 2005).

The question of gender in regard to system thinking remains unresolved. Do males and females apply system thinking differently? Though not many studies have examined this question with a K-12 sample, the general results so far are mixed.

Sweeney and Sterman (2000) first educed a gender effect, discovering that men consistently scored better on all of their three tasks than women. The tasks were presented to elite business school students and had been conceived to assess basic system thinking concepts such as feedback, time delays, and stock flows. The gender effect observed by Sweeney and Sterman was marginally significant and they emphasized more research is required to gain more conclusive findings. Moreover, they ascertained that even elite business school students show a weak relationship between prior education and performance on the system thinking tasks, despite many of the students having years of coursework, undergraduate and graduate degrees in mathematics, engineering or science. “The results strongly suggest that highly educated subjects with extensive training in mathematics and science have poor understanding of some of the most basic concepts of system dynamics, specifically, stocks and flows, time delays, and feedback. The errors are highly systematic, and indicate violations of basic principles, not merely errors in arithmetic or calculation.” (Sweeney & Sterman, 2000: 276)

In comparison, Ossimitz (2002) has also found a poor general performance of University business students when given system thinking tasks, with these tasks focusing on discerning between stock and flows in practical situations. A pretest and posttest was conducted around a crash course of 90 minutes on basic stock-flow concepts. In this study, males performed consistently higher than females. This came as a surprise, for the females did not differ from males in their math grade obtained on the school leaving exam. Even after the crash course, men performed better than women and the gender difference had not been closed. Ossimitz refrained from speculating on this effect and called for more research on the issue of gender and system thinking.

In 2006, the system thinking skills of 223 undergraduate Diploma students of the fields of Science and Technology, Business and Management, Social Sciences and Humanities were studied by researchers Kien-Kheng et al for the Universiti Teknologi MARA. This study aimed to quantify informal system thinking skills, as the students participating did not receive prior education or training in system thinking. The students had been given non-routine problems to solve and five system thinking skills were evaluated using similar instrument as Ossimitz (2002): Dynamic Thinking Skill, System-As-Cause Thinking Skill, Forest Thinking Skill, Operational Skill and Closed-Loop Thinking Skill.

The researchers found no significant gender difference ($p>0,05$), though generally the sample of students performed poorly. Though no difference in gender performance was observed, Kien-Kheng et al discovered a significantly better mean score of the Diploma students for Science and Technology than those from Business and Management, Social Sciences and Humanities. They explained this finding by the prior exposure of Science and Technology students to the basic concepts of system thinking such as behavior over time graphs, feedback, and understanding of probability, logic and algebra.

Kasperidus, Langfelder and Biber examined the system thinking skills of German school and university students in 2006. They selected 10th grade Gymnasium classes with 54 students aged 15-17 years and compared them to university students of a forest science diploma course and students of a Master of Science in Sustainable Research Management, both groups of the Technical University München. They subjected all of them to a Bathtub Dynamics test that required simple algebra and straightforward logic as well as an understanding of stock and flow relationships, time delays, and graphical integration. Overall the results were poor despite the Sustainable Research Management students having attended a lecture on system thinking and system dynamics, but no correlation could be found between education and performance.

No correlation between age and performance could be found either, though it is speculated that system thinking skills are honed by experience and a connection is drawn to the study of Capelo and Dias (2005), which discovered that managers with multiple years of work experience performed better than student groups in Bathtub Dynamics tests.

The male participants of this study repeatedly outperformed the female participants, especially in the high school group. The gender difference by the high school pupils was highly significant, whereas in the case of Sustainable Research Management students they could only find a slight significance in a specific task, but overall gender did not seem to influence this group's performance. In the forestry student group, a slight significance could also be determined in gender performance. They speculated that the gender difference in performance between males and females decreases with age and experience, in which case female pupils should receive more support for developing system thinking skills in this time period.

2.4 Implementation of System Thinking in Schools

Steps have been taken to implement systems thinking in secondary and even primary education, aiming to better prepare the next generation for the complex problems they will have to face or are already facing. NSF and NASA jointly fund the educational program GLOBE for this purpose, which envisions a "worldwide community of students, teachers, scientists, and citizens working together to better understand, sustain, and improve Earth's environment at local, regional, and global scales." and hopes to "contribute to scientific understanding of Earth as a system". (GLOBE, 2011)

Debra Lyneis believes that systems education can be brought to any kind of school (2000). In the United States, it has been implemented into the curriculum in a wide variety of schools, such as the middle schools of rural coastal Georgia, the public high schools and a parochial high school in Portland, Oregon, a private elementary day-school in Toledo, Ohio, an inner-city New York school, a charter school in Chelmsford, Massachusetts, rural schools in northern Vermont, and suburban schools in Carlisle and Harvard, Massachusetts. She says it is believed that the best place to start with a systems approach is at the middle school level due to the development of the students and the flexibility of the school structure, but elementary schools and high schools have successfully employed systems thinking in lessons as well.

At Orange Grove Middle School in Tucson, Arizona, system thinking has been applied in the science curriculum since the fall of 1988 in a program called Directed Learning (Draper, 1991). Scandinavian countries are also working together to use system dynamics as a foundation for their educational system (Forrester, 1992).

With help of the STELLA software developed by Barry Richmond in 1987, system thinking has been introduced to several schools in the United States as an approach for students ranging from kindergarten through 12th grade. STELLA is based on system dynamics modeling, which is implemented in the software in a manner simple enough to be used as a tool even by children of elementary school age (Sommer, 2005).

Promoted by Jay Forrester, system dynamics has managed to set foot in classrooms from kindergarten to 12th grade. Teachers who implemented the principles of system dynamics in their curriculum reported the extent of their success to him, for example (Forrester, 2010: 2-3):

> From Jan Mons, at a school in Georgia: "My most fruitful experiences occur when I discuss classroom discipline systems. We have both students and teachers build a discipline system together so that all parties will know what the system is capable of producing. When we do this many students have an "Aha!" experience and state that they now understand how a teacher's frustration can accumulate over time. Teachers have their own insights as well--they begin to understand how they have often built discipline systems that were "preprogrammed" to result in unpleasant situations."
>
> Tim Joy at a high school in Portland, OR: "I taught writing and literature for 13 years and always suspected I was party to some intellectual crime. Why is it that so many students thought the world of language began and ended at the door of the classroom? Then I discovered system dynamics. …System dynamics has a logic-based grammar, a universal language that students can readily learn and manipulate to create meanings. What have I found? Creating "meaning" results in bolder QUESTIONS, whole new views which do not house traditional understandings."

In the United States, the trend to introduce system thinking to classrooms has been growing steadily for over a decade. A wide range of computer simulation tools and other teaching elements are available for teaching, promoted and developed strongly by Forrester and Meadows. In comparison, European schools are lagging behind, especially in German-speaking regions. In order to remedy that, a project group has been founded in Switzerland by the Pedagogical University of St. Gallen (PHSG) to help research and promote system thinking in elementary schools, SYSDENE. Their focus lies on didactic methods and the development of the curriculum, and they offer to teach staff how to best employ methods of system thinking in their curriculum in exchange for participating in their research projects dedicated to refining these methods.

SYSDENE published a book in 2010 as a guideline for German-speaking teachers on how to encourage children to think in networks and view situations from different perspectives, *Systemdenken fördern – Systemtraining und Unterrichtsreihen zum vernetzten Denken* written by Sandra Wilhelm Hamiti et al. It offers designs for curriculum units for grades 1 through 9 in multiple subjects, and offers examples on how to practice and nurture the student's acquired systemic knowledge with activities and playful training to motivate them. The methods advised in this book have been tested in their prior studies.

In Germany, schools can compete in a nationwide project called Ecopolicyade in which students between grades 7 to 10 can participate to test their skills at running imaginary countries in the cybernetic computer simulation game Ecopolicy designed by cybernetics expert Frederic Vester. The competition was launched in 2005 after ninth-grade students had managed to defeat members of the German Bundestag in a game, and it runs under the motto of "think in networks, master the present, shape the future". Prof. Dr. Fredmund Malik states on the official website of Ecopolicy: "Ecopolicyade has brought forth a new generation of system thinkers." A pilot project has also been started in Austria and the Netherlands in attempt to begin internationalizing the competition. In addition to teaching the students how to work with the computer simulation, their curriculum is reshaped to cater to more interdisciplinary approaches.

In addition to system thinking principles being introduced into classrooms, the internet has also become a growing source of tools for teaching and training thinking in systems. For example the website www.clexchange.org provides resources, guidelines, books and many more services to help teach about systems. Another example of a website dedicated to this cause is Systems Thinking World (www.systemswiki.org) which offers free web seminars on systems thinking, modeling and simulation, has its own YouTube channel, and provides links to journals and eBooks on system thinking for further reading. It is also one of many websites to offer free tools for creating your own maps of systems, simulations or models.

3. Methods

3.1 Process of this study

As several studies have been made on the subject of system thinking skills of adults and college students, I wanted to aim this study at a younger target group. I chose the category of students beginning their 11th year of school at around 16-17 years of age, because I believe at this phase in life young people begin to solve complex problems in daily situations more and more independently, but still lack the experience that might guide them later in life. Fewer studies have been done on children and teenagers, so I decided to choose an explorative method for this study in the form of a paper-and-pencil test.

I decided to target students of a uniform educational level, and decided on gymnasium students, the highest level of high school education in Austria (see Type of Gymnasium, page 31) since the student group of highest academic success could be expected to perform the best in a test of systemic skills, though a study has yet to compare the system thinking skills of various Austrian educational levels.

The test consisted of the system "everyday stress of a school student", which included the relationships of private life, school performance and stress (see Appendix, page 104.). Since I believe all students should be able to relate to this everyday-life system, previous knowledge on this subject was not necessary and was not assessed. Without requiring previous knowledge, I felt it would be easier to compare the different classes and I believed it would lessen the chance of students having already memorized a similar system than if I had for example chosen the digestive system. Moreover, since the topic of a pupil's every day stress is personal and not bound to a specific school subject, I hoped it would be a topic of interest to all of the participants and not a select group.

The students remained anonymous, except to identify guardian permission to participate in this study. Additionally, data on age, gender, school type, previous experience with concept maps, number of languages spoken fluently, and frequent contact to peers who live in other parts of the world outside of Austria was gathered to determine possible correlations.

A concept map was used to assess the students' level of understanding of a system as is discussed by Assaraf and Orion (2005) (see chapter 2.2, page 20), or at least the extent of which they were willing to display in this test. I decided on using a concept map that allowed the creation of non-hierarchical networks with the connections and relationships to be determined freely by the students. A minimum of elements was pre-determined to help clarify the basic nature of the stress system aimed for in this study. A simple example of a concept map was given for students to better understand the task. After drawing the concept map the students answered a few open-response questions to further asses their system thinking skills. The concept map should serve as a tool to assess the system thinking skills needed for the characteristics 1-5 identified by Assaraf and Orion (2005). The open-response questions should help assess the skills for characteristics 6-8.

I first pre-tested the method on 5 individuals ranging from 15-19 years of age outside of school. They were issued the task of drawing the same concept map as finally used in this study, and I took note of how much time on average the participants required to complete it. Furthermore, I asked them to pose any questions out loud that occur to them and noted these as well, so that I could refine the formulation of the task to make it more comprehensible and minimize misunderstandings. The students required about 10-20 minutes to create a concept map, which made me feel confident that on a larger scale I would be able to conduct the study in classrooms within one school period.

The participants of the pre-test were then given the three additional open-response questions to answer, and again I asked them to voice any questions they have concerning the task out loud so that I could take note of them and adjust the wording of the questions to make them more easily understandable. Again I observed the time these students needed to write out replies, and it took around quarter of an hour. I concluded this timeframe allowed for sufficient buffer time for introduction and explanation of the study in front of a classroom, as well as distributing and collecting the tests and answering questions within one school period. I therefore did not need to adjust the test in regard to timeframe. Minor adjustments were made to the questions in the test to clarify the objectives.

I applied to various gymnasiums in Vienna and received permission by 20 different gymnasiums to issue a paper-and-pencil test to students in the beginning of their 11th year of school. The schools contained a selection of different types of gymnasiums common in Austria, the *humanistisches Gymnasium*, *neusprachliches Gymnasium*, *Realgymnasium*, and *wirtschaftskundliches Realgymnasium*.

In most of the cases I personally conducted the test for each class in a cover lesson for an absent teacher in the presence of the substitute teacher. On three occasions it was not possible for me to be there personally at the time of testing due to time constraints of the available cover lessons. Therefore, the teachers were given instructions and most had already attended a previous testing with me in a different class.

After introducing myself in front of a class, I then passed out the tests without going into detail about the background of this study. I had decided not to explain the study until after the students took the test to avoid influencing the responses. Students individually filled out the tests and were permitted to ask questions to help clarify the tasks. Toward the end of the period the tests were collected again and I was then prepared to answer questions to the background of the study if so desired.

After converting the data into a spreadsheet, I then evaluated the data with IBM SPSS Statistics Version 19. Correlations were determined by Mann-Whitney U tests, as normal distributions were not given (see Data Analysis, page 35).

3.2 Age and Gender

Though all studied classes are 11th grades, the variety of age spans from 15-19 years. Questions I wanted to examine are: Do older students perform better on this test due to additional life experience and further development? Or do students regardless of age find themselves at a similar stage of system thinking skills development within the same grade?

Before many of the tests, I asked the teacher whether they believed the male or female students would more likely use a more holistic approach for the concept map. Interestingly, all teachers believed the female students would do this more frequently, as they reported females to be more precise, careful and lengthy with their answers, or attributed networking and a “cycle style” of responses to females, and a “listing style” of responses to males. Regarding gender, I wanted to see if these assumptions held up in the results.

3.3 Type of Gymnasium

Since a different type of school will to a certain extent have a different approach to teaching, I decided to check if there is a correlation between the application of system thinking skills and the different types of Austrian gymnasiums. I have summarized these types into two subgroups to avoid unrepresentatively small sample sizes. The two groups I will be looking at are *Gymnasium* and *Realgymnasium*.

Gymnasium

In this type of secondary school, at least two modern foreign languages like English and French are taught. In addition to the *neusprachliches Gymnasium*, I included the *humanistisches Gymnasium* in this group, in which ancient languages are preferred over modern ones, often in conjunction with Latin or a third modern language. This group as a whole contains schools that have their focus on language and arts instead of science, economy or mathematics.

Realgymnasium

The curriculum of this secondary school type aims to expand general knowledge and stresses the instruction of natural sciences and mathematics, usually in place of a third modern foreign language. Included here are any schools that have an emphasis on science fields, mathematics, business or economy, such as the *wirtschaftskundliches Realgymnasium*.

3.4 Fluent Languages and International Peers

As part of the data I collected for this study, I asked about the amount of languages spoken fluently, as well as if there is frequent contact to peers abroad. In order to fluently speak a language, it is almost impossible not to learn about the culture connected to the language. Already within a language itself the mentality of the culture is embedded in expressions, vocabulary and word constructions. In the case of teenagers, the reason for speaking more than one language fluently will most often either be a multi-lingual heritage or after having studied it for many years in school. Migration or a strong personal interest can also lead to learning a new language fluently. In all of these cases, the student is confronted with the mentality of the corresponding culture as well.

Seeing the same situation being treated differently and causing different reactions in different cultures will increase the awareness and practice in viewing situations from multiple perspectives. With the aspect of language as a parameter, I wanted to see if being well-practiced in keeping different perspectives in mind would make it easier to see the “big picture” and to view a situation as a dynamic system than if you are less frequently challenged to consider the situation from various angles.

The same thought process is behind the question of frequent contact with peers abroad. Current world events and trends have a different impact on different parts of the world, and I believe that teenagers who have the opportunity to experience the discrepancies when discussing these events with international friends have an advantage to viewing the world around them in dynamic systems rather than a simple chain of cause and effect.

3.5 Hidden Factors

As the study has an explorative character, no specific result can be expected beforehand. Both a correlation and lack thereof to any factor is worthy of discussion, as it can give us better insight on the application of system thinking in Austrian gymnasiums. Hidden factors however must be kept in mind that could distort the results.

In general I must emphasize that the results are not a direct reflection of the individual students' cognitive ability to think in systems. The only thing one can conclude directly by this study's results is the problem solving strategy the students actually applied, in other words the extent of the application of their system thinking skills. A concept map consisting of a circle of causalities is simpler to create than a network with feedback loops and dynamic relationships and therefore requires less system thinking, yet it can't be concluded that the student who drew a circle possesses less developed system thinking skills than the student who drew a network. It cannot be overlooked that drawing a circle also requires less time and effort than a network, and if a pupil isn't motivated to put time and effort into the tasks of this study, then he or she might have chosen a simpler problem solving strategy for that very reason. By taking averages, comparing frequencies, and testing for correlation I hope to at least detect trends in the decisions students make to solve problems when confronted with a test like this.

The difference in performance between classes of a same school could be influenced by different teachers, the atmosphere and focus in the classroom at the time of testing, the attitude of students toward an ungraded test during school hours or in a supplement class and their motivation to participate. In a case where a male student answered "no idea" to each of the three open questions, it is clear that his responses do not reflect his system thinking ability, but his mood at the time of testing. Each class I visited had its own character, ranging from a withdrawn, reflective class to a class that even during the time of testing appeared unable to concentrate quietly.

When examining the written questions, sometimes one answer would directly contradict the following answer. It is possible that the students simply do not see the connection between the context of the two questions and the resulting contradiction of their reply, but it is also possible that they employed an exam strategy of giving opposite answers to two similar questions in hopes of getting one of them right, especially when it is difficult to determine which side the examiner is looking for. This most often happened to the questions “does your concept map apply to all students in your grade” and “does your concept map apply to elementary school students and 12th grade students”, where I had tried to evaluate generalization. Since it isn’t clear in the test if it was “better” to answer with *yes* or *no*, it is possible that some students opted to choose both as to have at least one correct answer.

In this study, I was furthermore not able to determine the extent of practice the students might have had with applying system thinking skills beyond asking about prior experience with concept maps. System thinking skills however can be honed and practiced in many other ways, too.

Teachers are a further hidden factor. I experienced a large variation in the amount of time and control teachers submitted to me and to the pupils while undertaking this study. The personality of the teacher was likely an influence on the motivation of students and probably helped determine how serious the study was taken. It was also not possible for me to be present personally at each of the tests, so it is possible that teachers without my presence introduced the test to their class in a different manner than I did, and perhaps my presence influenced the motivation of the students. Furthermore, when a teacher conducts a test it is more likely for students to feel the pressure of an exam rather than the explorative nature of a study.

Another hidden factor are the discrepancies that can result in my interpretation of a pupil’s concept map or their written responses compared to what they had actually intended. It is possible that I sometimes misunderstood the intention in a concept map, especially around dynamic relationships, or that I misunderstood the meaning of a student’s written answer to the open-response questions.

4. Data Analysis

4.1. System Thinking Skills Evaluation

The data analysis will be adapted from the study of Assaraf and Orion (2005: 523).

1. *"The ability to identify the components of a system and processes within the system*:" Elements, linkages and processes are counted and their means compared between the groups of students.

2. *"The ability to identify relationships among the system's components*:" Elements linked to 1 other element are counted, elements linked 2 other elements are counted, as well as 3 other elements and 4 or more, and then the means compared between groups.

3. *"The ability to identify dynamic relationships within the system*:" The mean sum of dynamic relationships is compared between groups.

4. *"The ability to organize the system's components and processes within a framework of relationships*:" This will be assessed according to page 37. The levels can be compared between groups.

5. *"The ability to understand the cyclic nature of systems*:" The amount of cycles (at least 3 elements need to be connected) is counted, then the mean compared among the student groups.

6. *"Understanding the hidden dimensions of the system*:" Elements can be classified into three levels. The lowest level will contain only the elements already pre-determined in the test. The middle level will contain additional elements that are related to those already pre-determined. The highest level will contain additional elements unrelated to the pre-determined ones, for example health or aggression.

7. *"The ability to make generalizations:"* This can be expressed by the student assessing if their created concept map is case-specific or general, as in the question 2 and 3 of the test. The answers can be classified as not understanding the question, failing to recognize an effect, an unspecific reply or a specific reply.

8. *"Thinking temporally: retrospection and prediction*:" Reflection on future consequences and influence of the past can be determined by questions 1 and 2 of the test. The answers can be classified as not understanding the question, failing to recognize an effect, an unspecific reply or a specific reply.

4.2 Concept Map Evaluation

The influence of the parameters gender, age, type of gymnasium, fluent languages, international peer contact and previous concept map experience on the collected data was calculated with a Mann-Whitney-U test with the program IBM SPSS Statistics Version 19 to find possible correlations, because the data does not match a normal distribution. Excluded for the parameters relevant to the concept map are 18 cases in which the concept map consisted of 4 or less elements, as these are half or less than the given 8 elements and I do not consider the task of drawing a concept map with at least these 8 elements sufficiently fulfilled.

The concept maps were ranked by following criteria that determined the predominant form of the concept map:

1 = Chain

2 = Fork

3 = Circle (without a cycle)

4 = Circle (with a cycle)

5 = Sun (without a cycle)

6 = Sun (with a cycle)

7 = Web (not interactive)

8 = Web (interactive)

9 = Network (not interactive)

10 = Network (interactive)

The forms of triangle and square were described by the digits 11 and 12. Nevertheless, these types were excluded as I did not feel the assignment sufficiently completed with only 3 or 4 elements.

The chain (1) describes any concept map that consists primarily of one long chain, without anything influencing the chain of elements except the preceding element. A fork (2) consists of at least one chain of elements that at some point splits into at least one more chain. The next two types are similar, but with an important difference. While 3 describes a concept map that only has the shape of a circle in the way the elements are connected, 4 means a circle that when considering the direction of the portrayed processes, also has a cyclic nature.

In type 5, the displayed concept map takes form of a sun, which is to say there is one central element with at least four other elements connected to it. The central element is visibly the key element in this concept map, though it is possible for there to be two interacting suns. The elements that sprout from the central element may have further connections like a tail or appendix, but only by 6 are these further elements connected in a way that creates at least one cycle.

For 7, many elements are connected to each other like in a web, though there are dead end elements with only one connection too. The processes do not lead to cycles or interaction however, and the connections thereby do not provide a feedback function. This is achieved with 8, which follows the same structure pattern as 7, but the processes create interaction.

Finally, there is the form of a network. In difference to the webs of 7 and 8, this form has many elements with at least four connections and no “loose ends” with elements of only one connection. In 10 the processes lead to interaction, in 9 the network simply connects all elements without a process looping back to an element.

Nevertheless, there can be exceptions to these definitions if the appearance of a concept map strongly suggested a different form than it would be by definition, for example when a concept map shows many elements sprouting four connections, but one element with only one connection, it will still qualify as a network and not a web. If a string of elements has a fork consisting of only one element, it will still be regarded as a chain and not a fork.

5. Results

5.1 Descriptive Statistics

Table 5.1.1

	N	Minimum	Maximum	Mean	Standard Deviation
Age in years	306	15	19	16,53	0,716
Total Elements	303	3	14	7,72	1,567
Elements C1	303	0	9	1,42	1,578
Elements C2	303	0	8	2,66	1,860
Elements C3	303	0	7	1,98	1,493
Elements C4+	303	0	8	1,66	1,533
Connections	302	3	24	10,21	3,489
Interaction	303	0	13	0,77	1,345
Cycles	303	0	18	1,04	1,804
Extra Elements	303	0	6	0,50	1,048
Type	303	1	12	6,72	2,673
Dynamic	303	0	15	2,56	2,714
Hidden Elements	303	0	3	0,15	0,421

Table 5.1.2

Gender	Frequency	Percent
Male	128	41,7
Female	179	58,3
Total	307	100,0
Excluded	1	

In this study, 308 students were examined, consisting of 128 males, 179 females and 1 of unspecified gender, as can be seen in Table 5.1.2. Of the 308 students, 2 didn't reveal their age (Table 5.1.1). The youngest age of the remaining 306 students is 15, the oldest 19. On average, the students are 16,53 years old with a standard deviation of 0,716. The frequency of 16-year olds is the highest, formed by 56,5 % of the 306 students as seen in Table 5.1.3. In comparison, only two of these students is 15 years old and 34,3 % of the 306 students is 17. A total of 8,7 % of the students who participated are older than 17, with 6 students having reached the age of 19.

Table 5.1.3

Age in Years	Frequency	Percent
15	2	0,7
16	173	56,5
17	105	34,3
18	20	6,5
19	6	2,0
Total	306	100,0
Excluded	2	

As seen in Table 5.1.4, 57 Students claimed to have previous experience with concept maps, whereas 241 declined. 10 didn't answer this question and will therefore be excluded from correlations with previous concept map experience.

Table 5.1.4

Concept Map Experience	Frequency	Percent
Yes	57	19,1
No	241	80,9
Total	298	100,0
Excluded	10	

When asked how many languages the students consider themselves to speak fluently, 21 students stated 1 language, 149 stated 2 languages, 109 stated 3 languages, and 28 stated they consider themselves to speak 4 or more languages fluently with 1 student not specifying an answer (Table 5.1.5). Data of students that did not specify the amount of languages they speak will not be considered when analyzing correlation between languages and other parameters.

Table 5.1.5

Fluent Languages	Frequency	Percent
1	21	6,8
2	149	48,5
3	109	35,5
4+	28	9,1
Total	307	100,0
Excluded	1	

155 students replied that they tend regular contact to peers outside of Austria, while 150 said they do not, with respective percentages of 50,8% and 49,2% divided almost equally. As seen in Table 5.1.6, 3 students did not specify if they maintained frequent contact to peers outside of Austria, and their data will not be considered for correlations to the contact parameter.

Table 5.1.6

Contacts outside of Austria	Frequency	Percent
Yes	155	50,8
No	150	49,2
Total	305	100,0
Excluded	3	

In total, of the 308 students, 303 created concept maps. They used a minimum of 3 elements, and a maximum of 14 elements. The mean lies by 7,72 elements with a standard deviation of 1,57 (Table 5.1.1). The most common number of total elements used to create a concept map is 8, with 54,1% of the students choosing this amount (Table 5.1.7). This is also the amount of elements predetermined by the task given to them. The 5 students that did not draw concept maps cannot be considered in analysis concerning parameters of the concept map.

Table 5.1.7

Total Elements	Frequency	Percent
3	9	3,0
4	9	3,0
5	9	3,0
6	13	4,3
7	44	14,5
8	164	54,1
9	32	10,6
10	14	4,6
11	6	2,0
12	1	0,3
13	1	0,3
14	1	0,3
Total	303	100,0
Excluded	5	

Of the 303 students that drew concept maps, 116 of them did not use elements that have only one connection (Table 5.1.8). The highest amount of elements with one connection is 9, and the most commonly used amount of elements with one connection within a concept map lies by 0, with a percentage of 38,3%. The mean amount of elements that are connected only by one relationship to another element is 1,42 with a standard deviation of 1,578 (Table 5.1.1). Excluded are the 5 students who did not create a concept map and therefore can't be counted to the amount of students that use 0 elements with one connection.

Table 5.1.8

Elements C1	Frequency	Percent
0	116	38,3
1	63	20,8
2	60	19,8
3	36	11,9
4	14	4,6
5	7	2,3
6	3	1,0
7	3	1,0
9	1	0,3
Total	303	100,0
Excluded	5	

Among the total of 303 students who created concept maps, 40 of them did not use elements that are linked by two connections. The highest amount of elements with two connections lies by 8, and the amount of elements with two connections most commonly used by students in their concept map is at 3 with 21,5 %, as can be seen in Table 5.1.9. The mean of elements with two connections used by students is 2,66, with a standard deviation of 1,860 as show in Table 5.1.1. These results exclude the 5 students who did not draw a concept map and therefore can't be counted to the amount of students that use 0 elements joined by two connections.

Table 5.1.9

Elements C2	Frequency	Percent
0	40	13,2
1	53	17,5
2	53	17,5
3	65	21,5
4	48	15,8
5	19	6,3
6	1	5,0
7	6	2,0
8	4	1,3
Total	303	100,0
Excluded	5	

Excluding the 5 students who did not draw a concept map, a total of 56 students did not use elements that are connected to others through three relationships, as seen in Table 5.1.10. The maximum amount of elements with three connections within a concept map lies by 7 and the mean by 1,98, with a standard deviation of 1,493 (Table 5.1.1). Elements with three connections to other elements are most frequently used twice in a student's concept map, with 29,7%.

Table 5.1.10

Elements C3	Frequency	Percent
0	56	18,5
1	61	20,1
2	90	29,7
3	48	15,8
4	35	11,6
5	5	1,7
6	5	1,7
7	3	1,0
Total	303	100,0
Excluded	5	

Of the total 303 students that fulfilled the assignment of creating concept maps, 67 of them did not use elements that are connected to four or more other elements. The highest amount of elements with four or more relationships to other elements lies by 8, and the most commonly employed amount of elements with four or more connections in the students' concept maps is at 1 with 34,0 %, as can be seen in Table 5.1.11. The mean of elements with four or more connections lies by 1,66, with a standard deviation of 1,533 as shown in Table 5.1.1. The 5 students who didn't draw concept maps are excluded.

Table 5.1.11

Elements C4+	Frequency	Percent
0	67	22,1
1	103	34,0
2	62	20,5
3	41	13,5
4	12	4,0
5	9	3,0
6	6	2,0
8	3	1,0
Total	303	100,0
Excluded	5	

In the 303 concept maps that were created by the students, a mean of 10,21 connections were drawn between elements to indicate their relationships, with a standard deviation of 3,489 (Table 5.1.1). The maximum amount of total connections between all elements used lies by 24, the minimum by 3. In total, 3082 connections were drawn. The most frequently used amount of connections between all elements of the concept map is between 8 and 10 with a cumulated percentage of 39,7%, as is shown in Table 5.1.12. The 5 students who didn't complete the concept map task are excluded.

Table 5.1.12

Connections	Frequency	Percent
3	11	3,6
4	5	1,7
5	7	2,3
6	11	3,6
7	20	6,6
8	37	12,3
9	43	14,2
10	40	13,2
11	32	10,6
12	30	9,9
13	22	7,3
14	13	4,3
15	12	4,0
16	9	3,0
18	2	0,7
19	3	1,0
20	1	0,3
21	2	0,7
22	1	0,3
24	1	0,3
Total	302	100,0
Excluded	6	

A small part of the total connections drawn between all elements in a concept map are interactive relationships. These are drawn either by arrows that point in both directions, or by two arrows pointing to and from an element respectively. Of the total 3082 connections drawn in the concept maps, only 232 of them were interactive connections with a percentage of 7,53%. A mean of 0,77 interactive relationships were used, with a standard deviation of 1,345, as seen in Table 5.1.1 and Table 5.1.13. The minimum lies at 0 with 185 of the students not having used them at all, which is about almost two thirds of the sample. The maximum is found at 24. Most commonly, only one interactive connections was used when employed at all, with a percentage of 18,5%. These results exclude the 5 students who didn't create a concept map as part of the assignment.

Table 5.1.13

Interaction	Frequency	Percent
0	185	61,1
1	56	18,5
2	35	11,6
3	18	5,9
4	4	1,3
5	1	0,3
6	3	1,0
13	1	0,3
Total	303	100,0
Excluded	5	

When at least three elements are connected by relationships in a closed and continuous flow, they are counted as a cycle. If elements are connected in a circle, but the direction of their interactions cannot be followed in one continuous flow, they are not considered to by cyclic and are not counted. As seen in Table 5.1.1, a total of 136 students added cyclic connections to their concept maps. The minimum lies at 0, the maximum at 18 with a mean of 1,04 cycles and a standard deviation of 1,804. Most often, if a cycle is employed, students use only one in their concept map as shown in Table 5.1.14. More than half of the participants however didn't include a cycle at all. The 5 students who didn't fulfill the task of drawing a concept map are not included.

Table 5.1.14

Cycles	Frequency	Percent
0	167	55,1
1	67	22,1
2	23	7,6
3	22	7,3
4	9	3,0
5	8	2,6
6	2	0,7
7	3	1,0
8	1	0,3
18	1	0,3
Total	303	100,0
Excluded	5	

In the assignment of drawing a concept map, 8 elements are already predetermined, but as part of the task it is optional to come up with elements of your own. These “extra” elements can either be additional elements to the already predetermined 8 elements, or new elements that replace of some of the 8 given elements. The extra elements are evaluated as either being similar to pre-existing elements, or completely new elements unrelated to those already given as part of the task, which will be discussed later under “hidden dimensions”.

Of the total concept maps drawn, 223 participants didn’t add any new elements (Table 5.1.15), which make up 73,6% of the total sample. In comparison, 80 concept maps have new elements, with a mean of 0,50 and a standard deviation of 1,048 as seen in Table 5.1.1. The maximum of new elements lies at 6, the minimum amount at 0. Among the extra elements, 121 are evaluated as similar to the predetermined elements, and 44 are considered completely new additions. Again the 5 participants are excluded who didn’t draw a concept map.

Table 5.1.15

Extra Elements	Frequency	Percent
0	223	73,6
1	39	12,9
2	22	7,3
3	13	4,3
4	2	0,7
5	1	0,3
6	3	1,0
Total	303	100,0
Excluded	5	

Hidden dimensions are aspects of the system that aren't apparent on the first glance. In this task, they would be aspects not already given in the pre-determined elements, such as health or financial influences. Of the parameter "extra elements", this takes the 44 new elements that aren't similar to existing ones. As seen in Table 5.1.16, 87,8% of the participants did not reveal hidden dimensions. The maximum amount was 3 with a mean of 0,15 and a standard deviation of 0,421. Compared to the number of new elements as discussed above, 27,67% of those are hidden elements. Excluded are the five students who didn't create a concept map.

Table 5.1.16

Hidden Elements	Frequency	Percent
No hidden dimension	266	87,8
1	31	10,2
2	5	1,7
3	1	0,3
Total	303	100,0
Excluded	5	

When relationships between elements were labeled, it was possible to differentiate between dynamic and static relationships. In dynamic relationships, one element contributes to the mutability of the other. For example "Student → goes to → School" would not be dynamic, as nothing about Student or School changes by this interaction. In the case of "Friends → motivate → Student", the state of Student is altered by Friends and the relationship is therefore dynamic.

About two thirds of the participants in this study used dynamic relationships in their concept map as seen in Table 5.1.17. In comparison, 95 either did not label their interactions or the interactions between elements weren't dynamic. The minimum amount of dynamic relationships was 0, the maximum 15, with a mean of 2,56 and a standard deviation of 2,714 as can be seen in Table 5.1.1. Students who omitted the concept map task are not included.

Table 5.17

Dynamic Relationships	Frequency	Percent
0	95	31,4
1	45	14,9
2	30	9,9
3	43	14,2
4	29	9,6
5	12	4,0
6	21	6,9
7	12	4,0
8	4	1,3
9	4	1,3
10	5	1,7
11	2	0,7
15	1	0,3
Total	303	100,0
Excluded	5	

The concept maps were sorted into several categories by type, which is explained in more detail in the chapter Data Analysis on page 37. The types are hierarchical in complexity, with Triangle and Square being exceptions due to their low number of elements. Only 3 of the 303 students who designed a concept map used a chain of elements as the type (Table 5.1.18). Most frequently, the pupils used a web type design, but without an interactive feedback between the elements, as in 16,5% of the drawn concept maps. Second most frequent type of concept map design was an interactive network, with 14,2% of the 303 pupils opting for such a system structure.

Table 5.18

Type	Frequency	Percent
Chain	3	1,0
Fork	21	6,9
Circle (no cycle)	17	5,6
Circle (with cycle)	26	8,6
Sun (no cycle)	34	11,2
Sun (with cycle)	36	11,9
Web (not interactive)	50	16,5
Web (interactive)	32	10,6
Network (not interactive)	23	7,6
Network (interactive)	43	14,2
Triangle	10	3,3
Square	8	2,6
Total	303	100,0
Excluded	5	

In addition to drawing a concept map, the participating students were asked to answer open-response questions in regard to the system "Stress in the daily life of a student" and the concept map they had designed in the first task. As explained in Data Analysis, page 36, the responses are reviewed on three aspects on a scale ranging from not understanding the question to giving a specific reply. The first aspect is that of generalization. Does the student see a possibility of applying the same concept map to all students in the same grade? Does it also apply to students of higher or lower grades?

As can be seen in Table 5.1.19, only 2,9% of the pupils seemed to not understand the questions, but 42,2% did not appear to believe that generalization of their concept map is possible. Of the remaining students, 25,8% replied with a vague response, which can be as short as a simple "Yes.", and 29,1% of the pupils were more specific in their response, going into their viewpoint in more detail and sometimes giving examples to explain. Two students didn't give an answer to the questions at all and are therefore excluded from these results.

Table 5.1.19

General	Frequency	Percent
Not understood	9	2,9
Failed to see effect	129	42,2
Vague answer	79	25,8
Specific reply	89	29,1
Total	306	100,0
Excluded	2	

Another aspect reviewed in the responses is the ability to reflect on the past and project into the future. Again two pupils are excluded from the results as they did not give any response, but only 2,6% of the remaining students didn't appear to understand the questions in regard to the aspect of future and past. In this regard, only 10% of the pupils did not seem to see a connection to the past or future, and 50,0% gave a specific response, explaining their reasoning and sometimes giving examples to illustrate.

Table 5.1.20

Future/Past	Frequency	Percent
Not understood	8	2,6
Failed to see effect	31	10,1
Vague answer	114	37,3
Specific reply	153	50,0
Total	306	100,0
Excluded	2	

I have categorized the types of gymnasium according to chapter 3.3, page 31, and this is the frequency of students attending each type for this study: With 53,4%, the Realgymnasium is the most represented in this study. The remaining 46,6% of the students attended a Gymnasium (Table 5.1.21).

Table 5.1.21

Gymnasium Type	Frequency	Percent
Realgymnasium	164	53,4
Gymnasium Type	143	46,6
Total	307	100,0
Excluded	1	

5.2. Correlations

5.2.1 Correlation to Gender

Of the parameters tested against gender for correlation, four proved to be within the range of significance that directly related to the concept map: elements with four or more connections to other elements, interactive connections, extra elements not predetermined by the assignment, and type of concept map.

System thinking skills unrelated to the concept map that correlated with gender were the ability to make generalizations, and reflection on the past with conclusions about the future. Gender furthermore correlated to age and amount of languages spoken fluently.

Gender to C4+

Table 5.2.1

Female Students

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Elements C4+	167	8	0	8	1,60	1,521	2,314
Interaction	167	13	0	13	0,57	1,328	1,764
Extra Elements	167	6	0	6	0,62	1,196	1,431

Table 5.2.2

Male Students

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Elements C4+	118	8	0	8	1,99	1,505	2,265
Interaction	118	6	0	6	0,84	1,233	1,521
Extra Elements	118	3	0	3	0,37	0,814	0,663

Table 5.2.3

	Elements C4+
Mann-Whitney-U	8031,5
Wilcoxon-W	22059,5
Z	-2,748
Asymptotic significance (2 sides)	0,006

Table 5.2.4

Elements C4+	Gender	N	Mean Rank	Rank Total
	Male	118	158,44	18695,5
	Female	167	132,09	22059,5
	Total	285		

As seen in Table 5.2.3, the correlation between elements sharing four relationships with other elements and gender is very significant, with p = 0,006. In Table 5.2.4, you can see the ranking results of the Mann-Whitney-U test, in which the males show a higher mean rank than the females. Rank 1 is the lowest rank possible, as in this case a higher amount of C4+ elements will be considered a higher rank. The rank total is higher by females, which is a result of the higher amount of females than males in this test.

When comparing the mean number of C4+ elements between male and female pupils as given in Table 5.2.1 and 5.2.2, the average amount for males is 1,99 and for females 1,60 within an equal range. For both male and female students, 8 C4+ elements in a concept map was the maximum amount, while the minimum was 0.

Table 5.2.5

Male Students

Elements C4+	Frequency	Percent
0	16	13,6
1	35	29,7
2	30	25,4
3	21	17,8
4	8	6,8
5	5	4,2
6	2	1,7
8	1	0,8
Total	118	100,0

Table 5.2.6

Female Students

Elements C4+	Frequency	Percent
0	34	20,4
1	67	40,1
2	32	19,2
3	20	12,0
4	4	2,4
5	4	2,4
6	4	2,4
8	2	1,2
Total	167	100,0

By comparing the percentages for female and male students for each amount of C4+ elements as listed in tables 5.2.5 and 5.2.6, it becomes apparent that the highest percentages by female students lie by 0 and 1 C4+ elements with 20,4% and 40,1% respectively. In comparison, the highest percentages by male students are found by 1 and 2 C4+ elements, with 29,7% and 25,4% respectively. Only 13,6% of the male pupils didn't use any C4+ elements in their concept map at all.

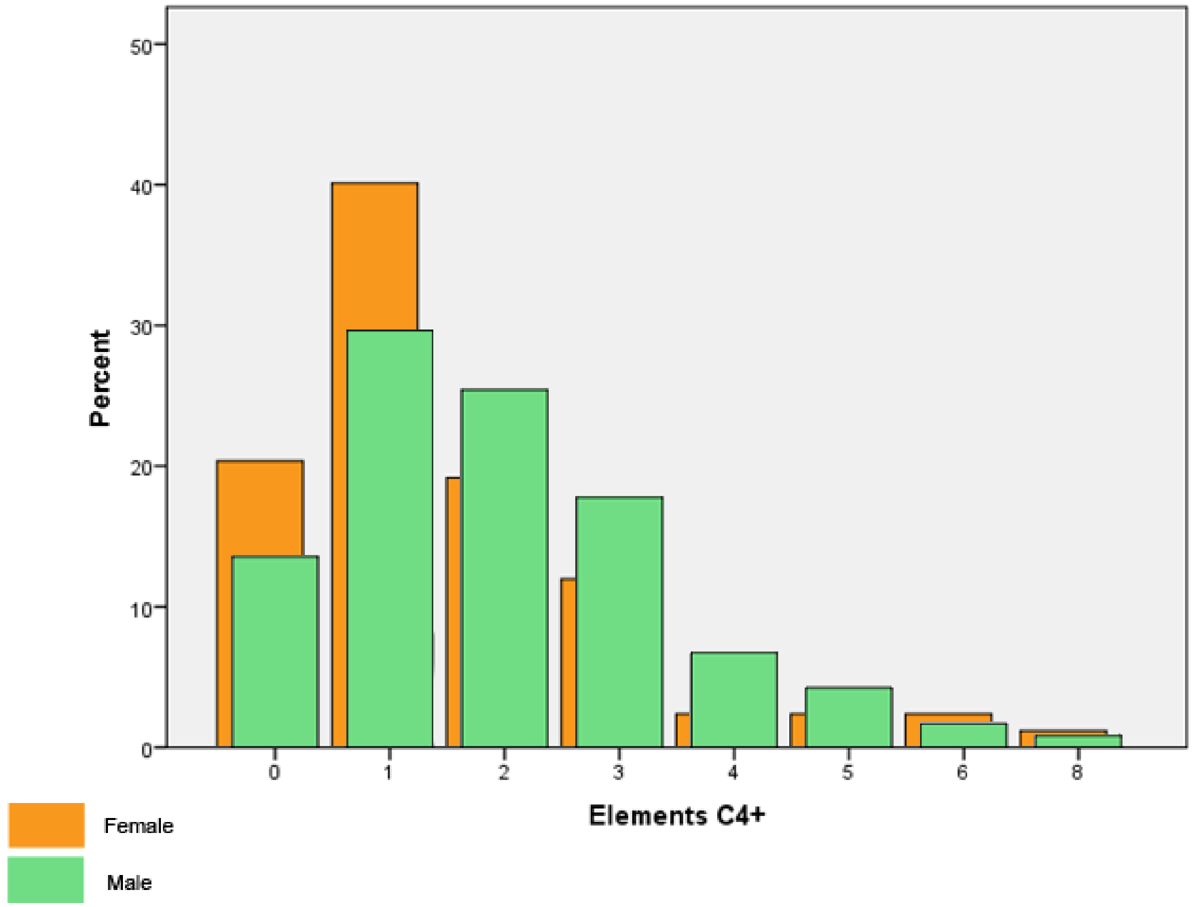


Image 5.2.1

In Image 5.2.1, a direct overlaying comparison between the male and female percentages show that the differences between the genders minimize the higher the amount of C4+ elements. The largest disparity occurs by the lowest amount of C4+ elements, by 0 and 1.

Gender to Interaction

Table 5.2.7

	Interaction
Mann-Whitney-U	8409,5
Wilcoxon-W	22437,5
Z	-2,462
Asymptotic significance (2 sides)	0,014

Table 5.2.8

Interaction	Gender	N	Mean Rank	Rank Total
	Male	118	155,23	18317,5
	Female	167	134,36	22437,5
	Total	285		

In Table 5.2.7 it shows that the amount of interactive relationships between elements correlates with a significance of p = 0,014 to gender. In this case males show a higher mean rank than females, as a higher amount of interaction is set equivalent to a higher rank, with a value of 1 being the lowest rank possible (Table 5.2.8). When the means between these two groups are compared (Table 5.2.1 and Table 5.2.2), female students average at 0,57 interactions, while male students average at 0,84.

Table 5.2.9

Male Students

Interaction	**Frequency**	**Percent**
0	66	55,9
1	24	20,3
2	18	15,3
3	5	4,2
4	3	2,5
6	2	1,7
Total	118	100,0

Table 5.2.10

Female Students

Interaction	Frequency	Percent
0	116	69,5
1	28	16,8
2	14	8,4
3	6	3,6
4	1	0,6
5	1	0,6
13	1	0,6
Total	167	100,0

Both female and male pupils have their highest percentages at the lowest amount of interactive connections, as seen in Table 5.2.9 and Table 5.2.10. For females, 0 and 1 interactions have 69,5% and 16,8% respectively. Male students used 0 and 1 interactions with a percentage of 55,9% and 20,3% respectively. Though both genders most frequently chose the lowest amounts of interactive connections possible, female students show an even stronger shift toward using no interactions at all. One female pupil however used more than twice as many interactive connections as the next highest amounts of either gender, employing 13 interactive connections in her concept map.

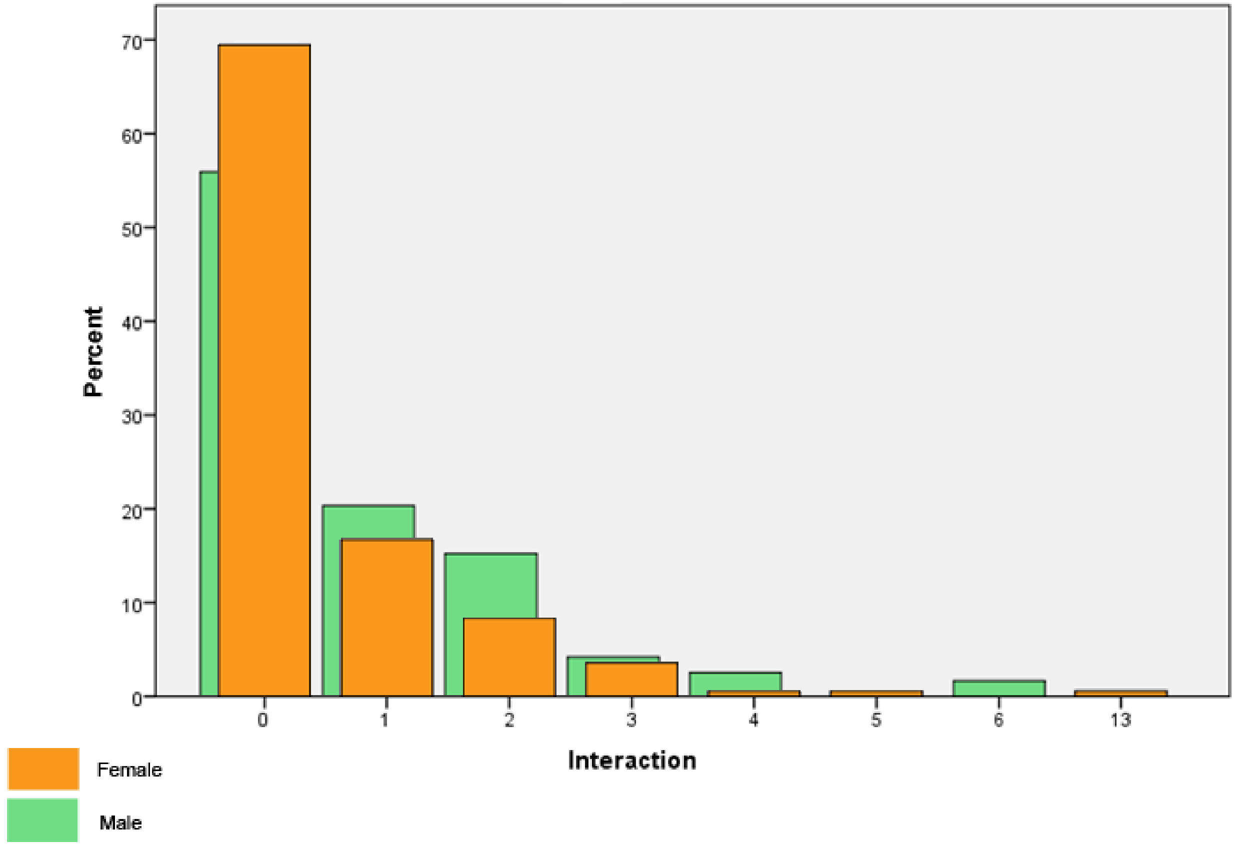


Image 5.2.2

The shift in percentages is visualized in Image 5.2.2 and shows that although the majority of both genders used a minimal amount of interaction, males employed them noticeably more often than female pupils. One female however used them much more frequently than any other student in this study.

Gender to Extra Elements

Table 5.2.11

	Extra Elements
Mann-Whitney-U	8787
Wilcoxon-W	15808
Z	-1,994
Asymptotic significance (2 sides)	0,046

Table 5.2.12

Extra Elements	Gender	N	Mean Rank	Rank Total
	Male	118	133,97	15808
	Female	167	149,38	24947
	Total	285		

A significance of p = 0,046 can be seen in Table 5.2.11, showing that there is a correlation between the newly formed elements and gender. In this case, female students show a higher mean rank than males, as a higher amount of extra elements is considered a higher rank. The rank total shows an even greater discrepancy between males and female pupils, because more females were tested in this case than males, as seen in Table 5.2.12. In this case, by comparing the means between male and female students as seen in Table 5.2.1 and Table 5.2.2, the females have an average of 0,62 while the males have an average of 0,37.

Table 5.2.13

Male Students

Extra Elements	Frequency	Percent
0	94	79,5
1	9	7,6
2	10	8,5
3	5	4,2
Total	118	100,0

Table 5.2.14

Female Students

Extra Elements	Frequency	Percent
0	114	68,3
1	29	17,4
2	11	6,6
3	7	4,2
4	2	1,2
5	1	0,6
6	3	1,8
Total	167	100,0

In the case of amount of new elements, male pupils have the highest percentages at 0 and 2, with 79,7% and 8,5% respectively. Female students in comparison most frequently employed 0 and 1 extra elements, with 68,3% and 17,4% respectively (Table 5.2.13 and Table 5.2.14).

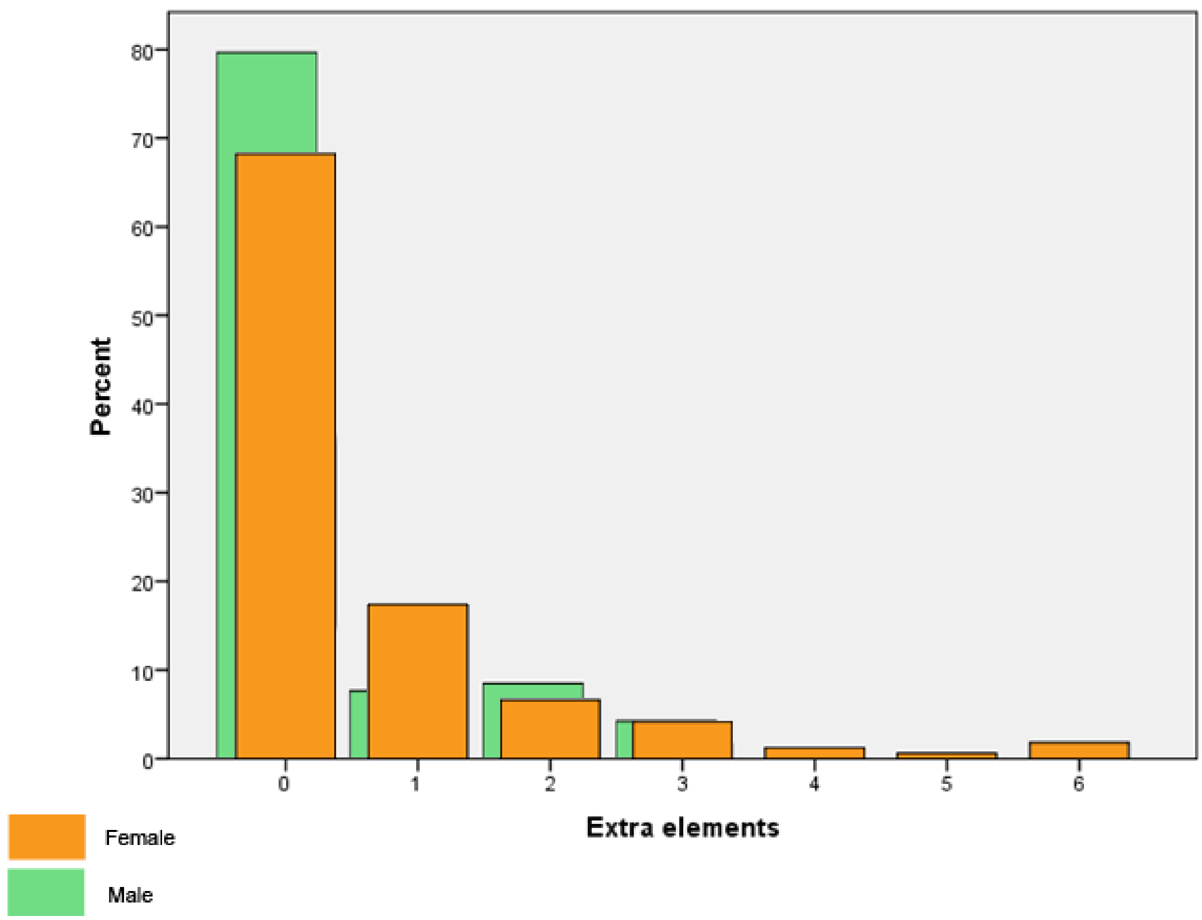


Image 5.2.3

As can be seen in Image 5.2.3, the highest discrepancies between male and female students occur at 0 and 1 extra elements. For female pupils, the maximum amount of new elements is 6, while for male pupils the maximum amount is 3.

Gender to Hidden Dimensions

Table 5.2.15

Hidden Dimensions

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Female Students	167	8	0	8	0,77	1,513	2,289
Male Students	118	5	0	5	0,46	1,027	1,054

Table 5.2.16

	Hidden Dimen.
Mann-Whitney-U	8815
Wilcoxon-W	15836
Z	-1,949
Asymptotic significance (2 sides)	0,051

Table 5.2.17

Hidden Dimen.	Gender	N	Mean Rank	Rank Total
	Male	118	134,20	15836
	Female	167	149,22	24919
	Total	285		

Although with p=0,051 (Table 5.2.16) this is not a significant result, it shows a possible tendency for a correlation between gender and the display of hidden dimensions. In the case of hidden dimensions within the system, female participants of this study appear to have a higher rank average than male participants, with rank 1 being the lowest possible score. Since the display of hidden dimensions require new elements to be added to the given list of elements in the system, the tendency for more females to reveal hidden dimensions goes hand in hand with the correlation of gender to extra elements. The mean average for female participants lies at 0,77, while the mean for males is at 0,46 (Table 5.2.15).

Table 5.2.18

Male Students

Hidden Dimensions	Frequency	Percent
No hidden dimension	94	79,7
1	6	5,1
2	10	8,5
3	5	4,2
4	2	1,7
5	1	0,8
Total	118	100,0

Table 5.2.19

Female Students

Hidden Dimensions	Frequency	Percent
No hidden dimension	115	68,9
1	20	12
2	14	8,4
3	7	4,2
4	4	2,4
5	3	1,8
6	2	1,2
8	2	1,2
Total	167	100,0

Both male and female students for the majority don’t display any hidden dimensions, as seen in Table 5.2.18 and Table 5.2.19. 79,7% of the male pupils don’t include them, and 68,9% of the female pupils.

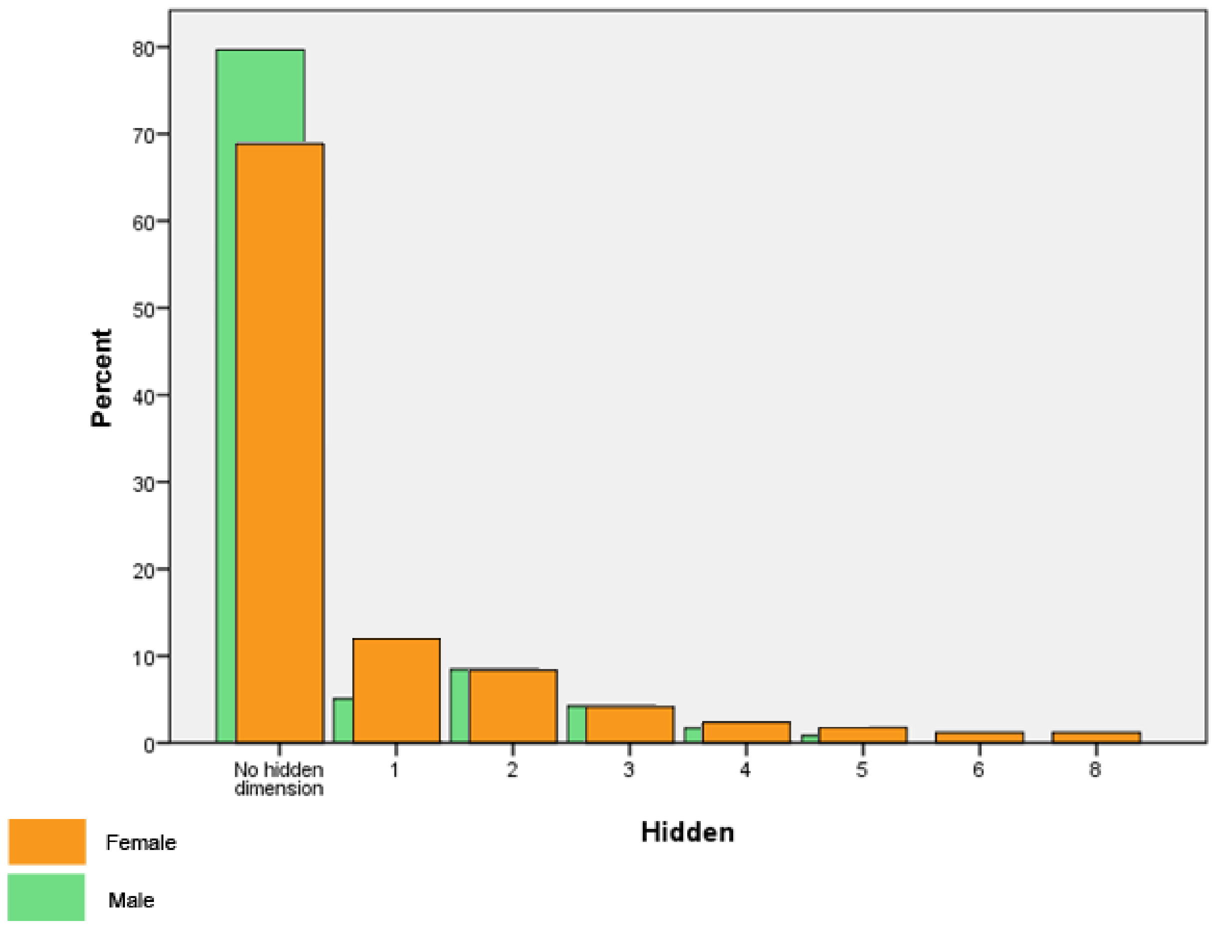


Image 5.2.4

There is a slight shift of females toward higher amounts of hidden dimensions in comparison to males as seen in Image 5.2.4, but it is not to a significant extent. The range of female participants is 0-8 hidden dimensions, while for male participants it is 0-5.

Gender to Type

As explained in Data Analysis on page 37, the type of concept map is hierarchically sorted by complexity and numbered 1-10. For this Mann-Whitney-U test on correlation, a higher value in type number is set equivalent to a higher complexity.

Table 5.2.20

Type of Concept Map

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Male Students	117	8	2	10	6,87	2,321	5,389
Female Students	167	8	1	10	6,08	2,516	6,330

Table 5.2.21

	Type of CM
Mann-Whitney-U	7983,5
Wilcoxon-W	22011,5
Z	-2,643
Asymptotic significance (2 sides)	0,008

Table 5.2.22

Type of CM	Gender	N	Mean Rank	Rank Total
	Male	117	157,76	18458,5
	Female	167	131,81	22011,5
	Total	284		

With a high significance of p =0,008, gender and type of concept map are correlated. Male students show a higher mean rank than their female colleagues, which indicate higher values for the type parameter (Table 5.2.21 and Table 5.2.22). The mean average value for type by female students lies at 6,08, while in comparison the value for type by male participants lies at 6,87 as seen in Table 5.2.20.

Table 5.2.23

Male Students

Type of Concept Map	Frequency	Percent
1 Chain	0	0
2 Fork	7	6,0
3 Circle (no cycle)	6	5,1
4 Circle (with cycle)	7	6,0
5 Sun (no cycle)	6	5,1
6 Sun (with cycle)	22	18,8
7 Web (not interactive)	23	19,7
8 Web (interactive)	14	12,0
9 Network (not interactive)	11	9,4
10 Network (interactive)	21	17,9
Total	117	100,0

Table 5.2.24

Female Students

Type of Concept Map	Frequency	Percent
1 Chain	3	1,8
2 Fork	14	8,4
3 Circle (no cycle)	11	6,6
4 Circle (with cycle)	19	11,4
5 Sun (no cycle)	28	16,8
6 Sun (with cycle)	14	8,4
7 Web (not interactive)	27	16,2
8 Web (interactive)	18	10,8
9 Network (not interactive)	11	6,6
10 Network (interactive)	22	13,2
Total	167	100,0

As seen in Table 5.2.23, the type values with the highest frequency are 7 and 6 by male pupils, with 19,7% and 18,8% respectively, and for female pupils the highest frequencies are found by type values 5 and 7, with 16,8% and 16,2% respectively (Table 5.2.24).

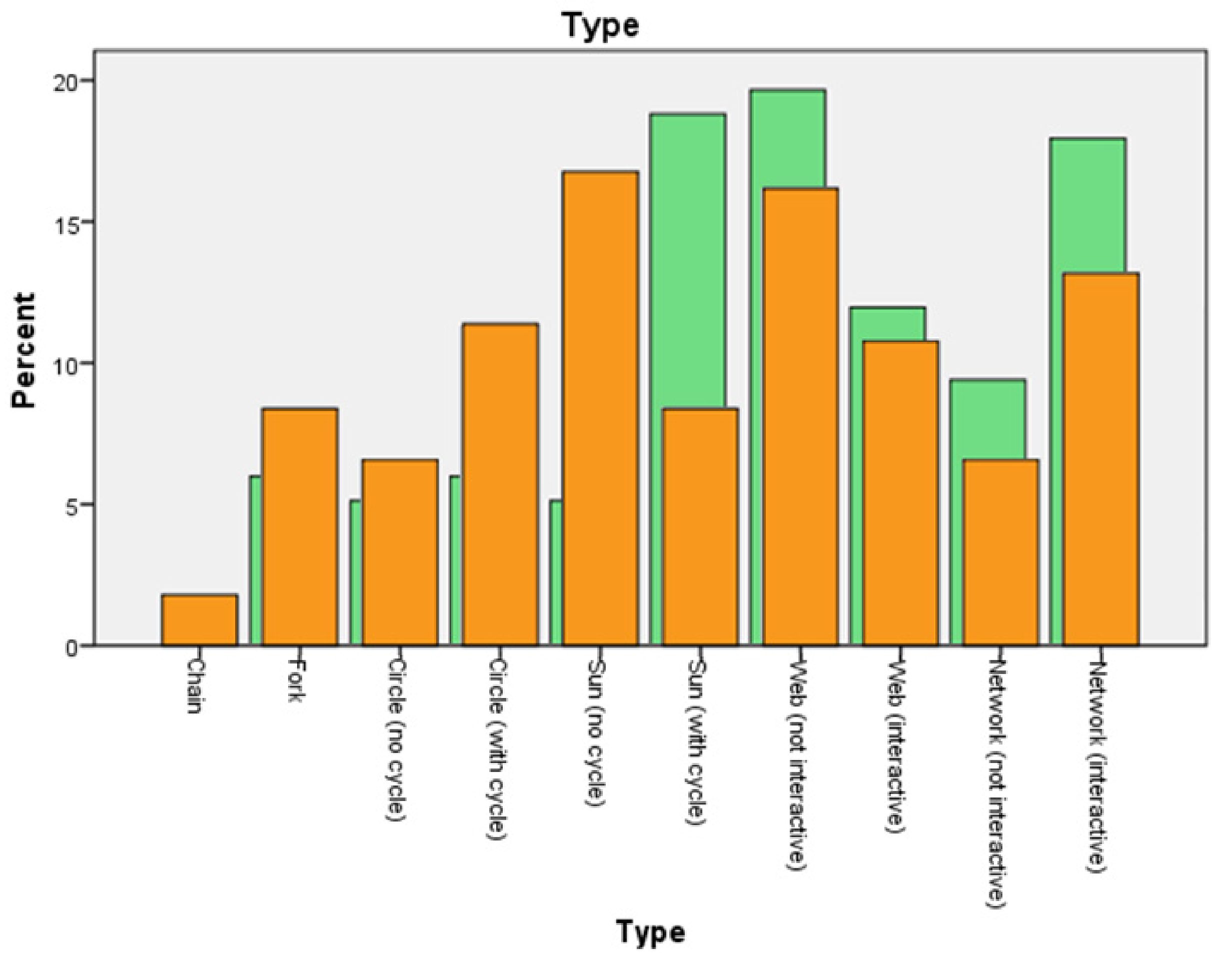


Image 5.2.5

In Image 5.2.5 the shift between female and male students is visible, and the highest discrepancy between the two genders occurs at the value 5, followed closely by 6.

Gender to Age

When comparing gender to the parameters unrelated to the concept map, three more correlations can be found, one between gender and age, the other between gender and the amount of languages spoken fluently.

Table 5.2.25

Age in Years

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Female Students	178	4	15	19	16,45	0,681	0,464
Male Students	128	3	16	19	16,63	0,752	0,565

Table 5.2.26

	Age
Mann-Whitney-U	9914,5
Wilcoxon-W	25845,5
Z	-2,193
Asymptotic significance (2 sides)	0,028

Table 5.2.27

Age	Gender	N	Mean Rank	Rank Total
	Male	128	165,04	21125,5
	Female	178	145,20	25845,5
	Total	306		

For the Mann-Whitney-U test, the ages 15-16 were grouped together, and the ages 17-19 were grouped together. I chose to do this because the amount of participants in this sample younger than 16 and older than 17 was too small in itself to be compared to the participants of 16 and 17 years of age.

As depicted in Table 5.2.26, there is a correlation between age and gender with a significance of p = 0,028. Males have a higher mean rank than females, which shows that there are more male pupils who are older than female pupils in this sample than female pupils who are older than male pupils (Table 5.2.27). On average however, males are 16,63 years and females 16,36 years old (Table 5.2.25).

Table 5.2.28

Male Students

Age in Years	Frequency	Percent
16	65	50,8
17	48	37,5
18	12	9,4
19	3	2,3
Total	128	100,0

Table 5.2.29

Female Students

Age in Years	Frequency	Percent
15	2	1,1
16	108	60,7
17	57	32,0
18	8	4,5
19	3	1,7
Total	178	100,0

Though both male and female students both have the majority of participants at the age of 16, females have a percentage of 60,7%, while males have a percentage of 50,8% (Table 5.2.28 and Table 5.2.29). In all ages above 16, female pupils have a lower percentage than male pupils. Only two of the participating students in this sample are 15 years old, and both of them are female.

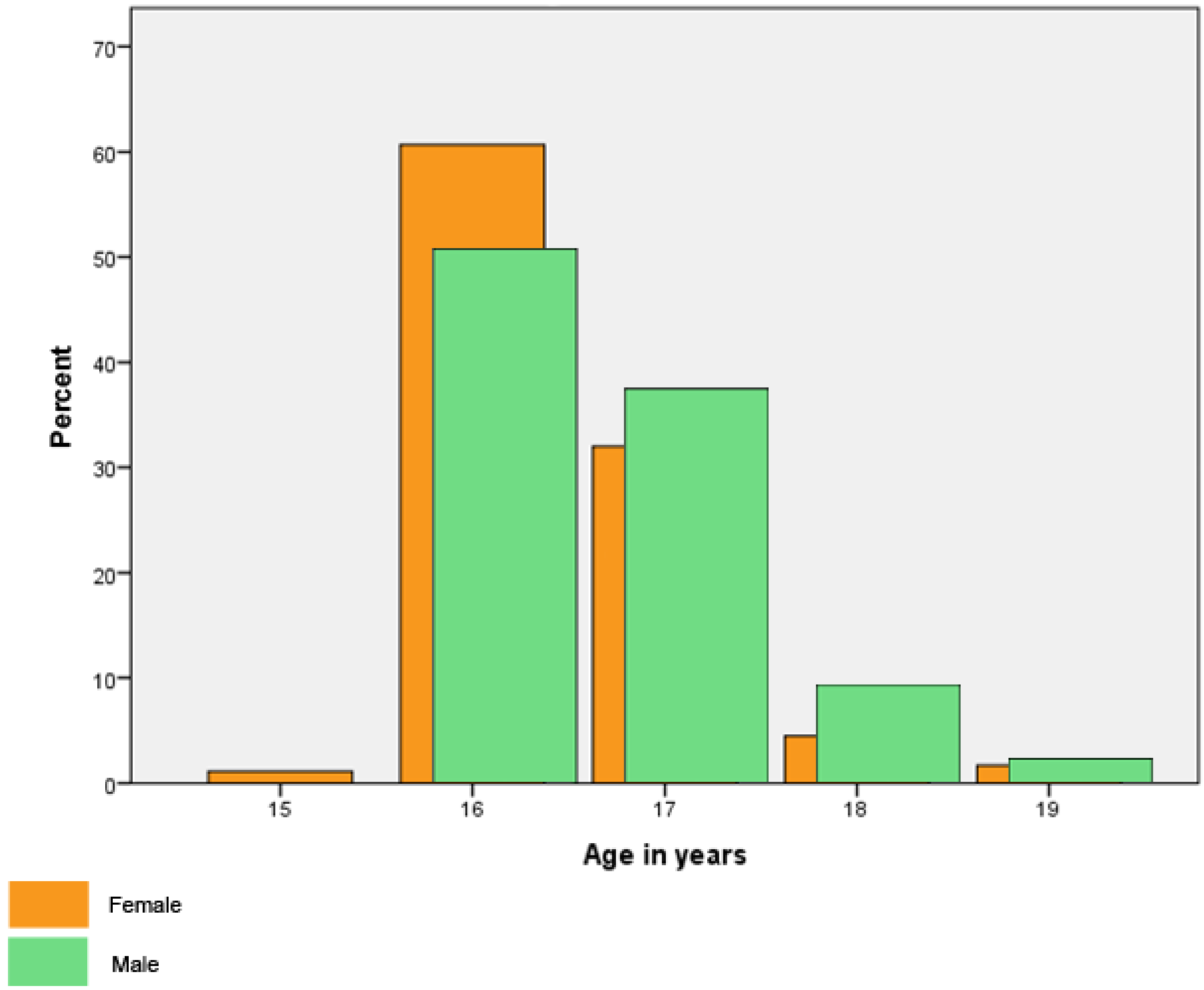


Image 5.2.6

The largest difference between the genders occurs at 16 years of age, as can be seen in Image 5.2.6. A slight shift between male and female students is visible in the image, with females slightly younger on average than males.

Gender to Fluent Languages

Table 5.2.30

Fluent Languages

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Female Students	179	3	1	4	2,55	0,736	0,541
Male Students	128	3	1	4	2,36	0,771	0,594

Table 5.2.31

	Fluent Languages
Mann-Whitney-U	9933
Wilcoxon-W	18189
Z	-2,167
Asymptotic significance (2 sides)	0,030

Table 5.2.32

Fluent Languages	Gender	N	Mean Rank	Rank Total
	Male	128	142,10	18189
	Female	179	162,51	29089
	Total	307		

The second of these correlations can be found in the category of languages spoken fluently. Table 5.2.31 shows a significance of p = 0,030 for the correlation between fluent languages and gender. This time, female students have a higher mean rank than their male colleagues, as seen in Table 5.2.32. Again, the lowest possible rank on this scale is 1, as a higher amount of spoken languages equals a higher value of the rank. When comparing the means between male and female pupils, the male participants average at 2,36, while the female participants average at 2,55 fluent languages spoken (Table 5.2.30).

Table 5.2.33

Male Students

Fluent Languages	Frequency	Percent
1	13	10,2
2	66	51,6
3	39	30,5
4+	10	7,8
Total	128	100,0

Table 5.2.34

Female Students

Fluent Languages	Frequency	Percent
1	8	4,5
2	83	46,4
3	70	39,1
4+	18	10,1
Total	179	100,0

Both female and male participants have their highest percentages 2 languages spoken fluently, as seen in Table 5.2.33 and Table 5.2.34. The lowest percentage for male students however is attributed to 4+ fluent languages, while for female students the lowest percentage is found by 1 language spoken fluently.

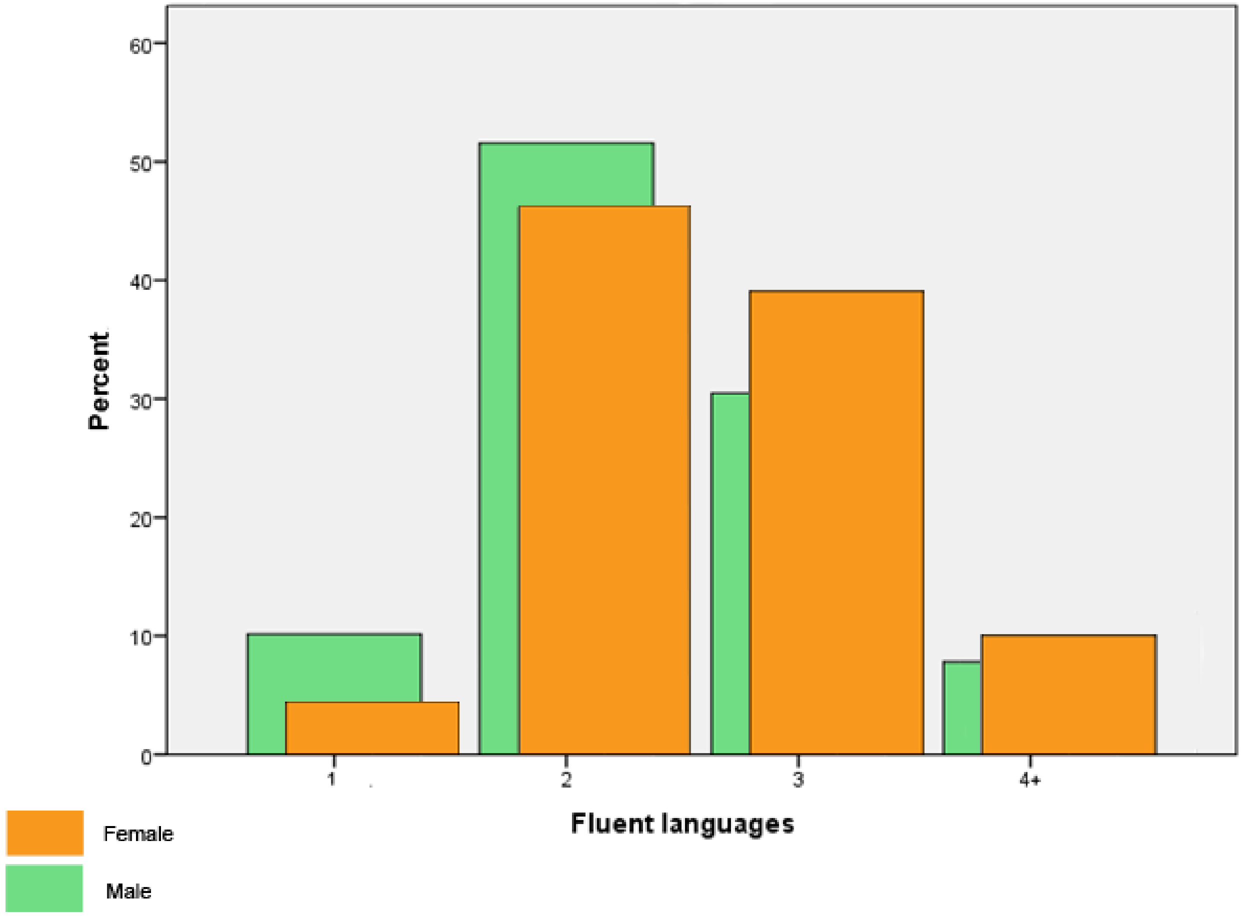


Image 5.2.7

Image 5.2.7 shows the shift of female pupils toward a higher amount of fluent languages spoken in comparison to their male colleagues, though for both genders the majority of participants speak 1 or 2 languages fluently, 2 being the predominant amount.

Gender to Type of Gymnasium

Finally, the third correlation between a parameter unrelated to the concept map and gender is found by the type of gymnasium the participants attended. For this, Realgymnasium was given the value “1” and Gymnasium the value “2”. For a more detailed explanation of these two types of schools, see page 31.

Table 5.2.35

Type of Gymnasium

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Females	179	2	1	2	1,59	3,293	10,846
Males	128	2	1	2	1,29	0,493	0,243

Table 5.2.36

Gymnasium	Gender	N	Mean Rank	Rank Total
	Male	128	126,87	16239,5
	Female	179	173,4	31038,5
	Total	307		

Table 5.2.37

	Gymnasium
Mann-Whitney-U	7983,5
Wilcoxon-W	16239,5
Z	-5,241
Asymptotic significance (2 sides)	0,000

Table 5.2.37 shows a very high significance of p = 0,000 for the correlation between the type of gymnasium attended and gender. Female students have a higher mean rank than their male colleagues, which means the value "2" for Gymnasium is more frequent by them, whereas by the male students the more common value is "1" for Realgymnasium (Table 5.2.36). When comparing the means between male and female pupils, the males average at 1,29, while the females average at 1,59 (Table 5.2.35).

Table 5.2.38

Male Students

Type of Gymnasium	**Frequency**	**Percent**
Realgymnasium	91	71,1
Gymnasium	37	28,9
Total	127	100,0

Table 5.2.39

Female Students

Type of Gymnasium	Frequency	Percent
Realgymnasium	73	40,8
Gymnasium	106	59,2
Total	179	100,0

As seen in Table 5.2.38, male pupils participating in this study attended the Realgymnasium with a predominance of 71,1%. Female students of this study show a little less defined tendency toward one type of school, but with 59,2% they attended the Gymnasium (Table 5.2.39).

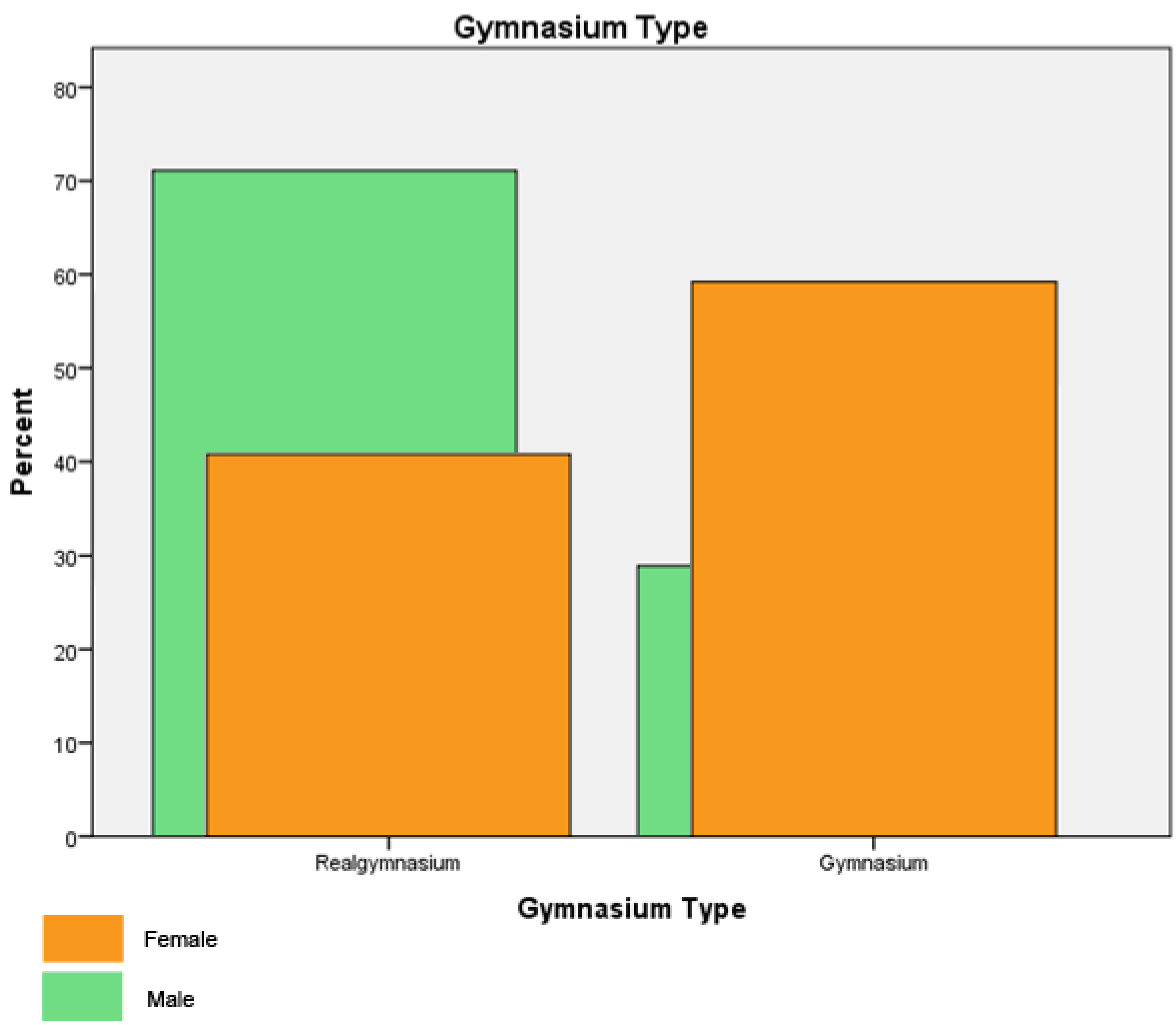


Image 5.2.8

Image 5.2.8 depicts the contrast between male and female participants, and show a clear preference of males for the Realgymnasium and a preference of females for the Gymnasium.

Gender to Generalization

Table 5.2.40

Generalization

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Male Students	127	3	0	3	1,57	0,841	0,707
Female Students	179	3	0	3	1,98	0,893	0,797

Table 5.2.41

Generalization	Gender	N	Mean Rank	Rank Total
	Male	127	136,96	17394,5
	Female	179	165,23	29576,5
	Total	306		

Table 5.2.42

	Generalization
Mann-Whitney-U	9266,5
Wilcoxon-W	17394,5
Z	-3,195
Asymptotic significance (2 sides)	0,001

For the open-response questions, the replies were evaluated as 0 = didn't understand the question, 1 = failed to see the effect, 2 = vague reply on the effect, 3 = detailed reply on the effect. The test revealed a highly significant correlation to gender with p =0,001 (Table 5.2.42).

As female participants show a higher ranking and 1 is the lowest possible rank, more female than male students recognized an effect and provided a more specific reply (Table 5.2.41). The mean of female pupils lies at 1,98, for male pupils at 1,57 (Table 5.2.40).

Table 5.2.43

Female Students

Generalization	Frequency	Percent
Not understood	3	1,7
Failed to see effect	64	35,8
Vague answer	46	25,7
Specific reply	66	36,9
Total	179	100,0

Table 5.2.44

Male Students

Generalization	Frequency	Percent
Not understood	6	4,7
Failed to see effect	65	51,2
Vague answer	33	26,0
Specific reply	23	18,1
Total	127	100,0

As seen in Table 5.2.44, the highest frequency is at Failed to see effect by male pupils with 51,2%, the next highest at 26,0% for Vague answer. For female pupils the highest frequencies are found by Specific reply with 36,9%, followed closely by Failed to see an effect at 35,8% (Table 5.2.43).

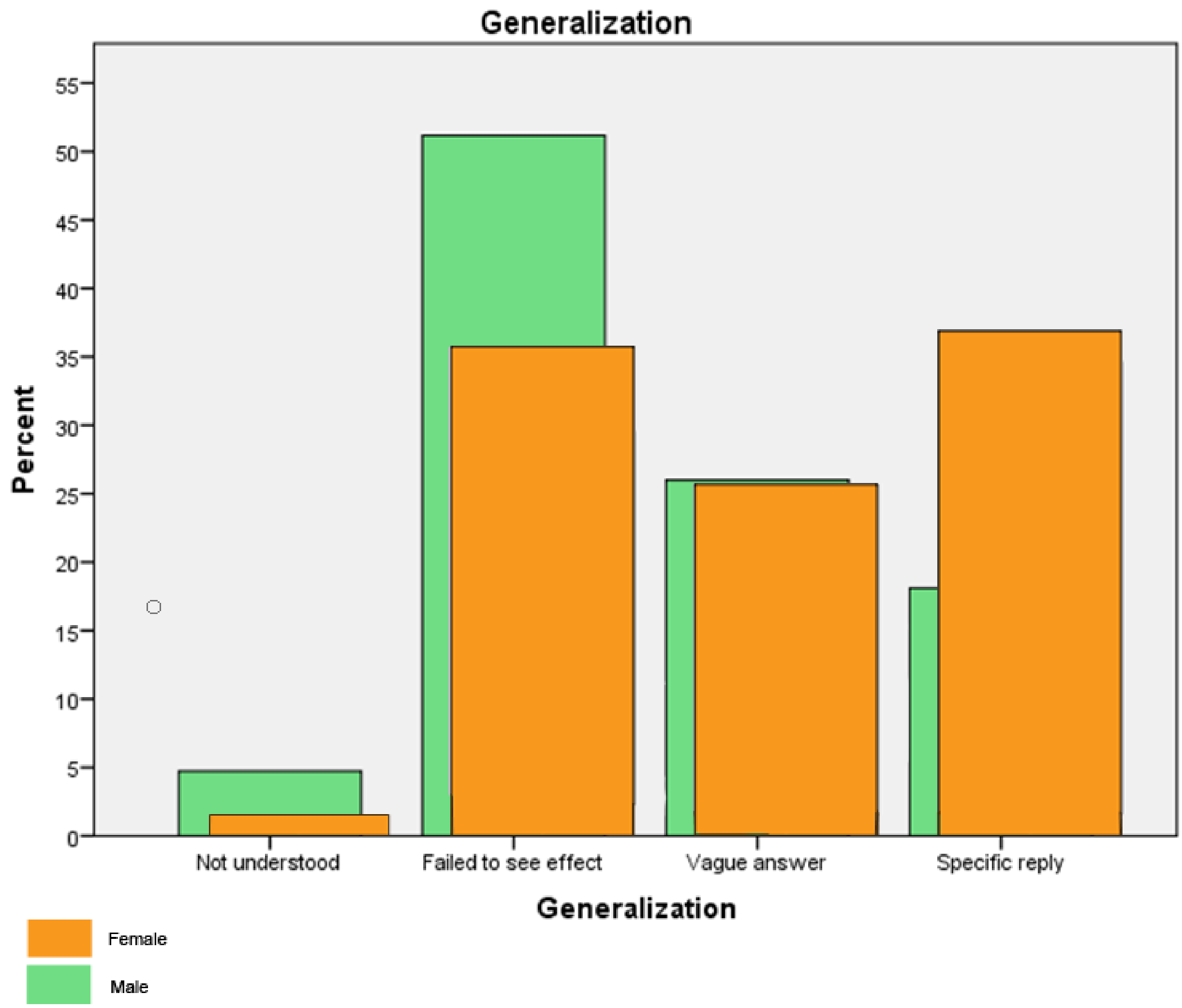


Image 5.2.9

Image 5.2.9 visualizes the shift between male and female participants, with the percent of male students clearly tending toward “Failed to see effect” while females have a higher percentage for seeing an effect and replying with a specific answer. The highest discrepancy between the two genders occurs at Specific reply.

Gender to Future/Past

Table 5.2.45

Future/Past

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Female Students	179	3	0	3	2,50	0,690	0,476
Male Students	127	3	0	3	2,13	0,820	0,672

Table 5.2.46

Future/Past	Gender	N	Mean Rank	Rank Total
	Male	127	130,74	16604
	Female	179	169,65	30367
	Total	306		

Table 5.2.47

	Future/Past
Mann-Whitney-U	8476
Wilcoxon-W	16604
Z	-4,180
Asymptotic significance (2 sides)	0,000

As with Generalizations, the replies of the open-response questions were evaluated as 0 = didn't understand the question, 1 = failed to see the effect, 2 = vague reply on the effect, 3 = detailed reply on the effect. The test revealed a highly significant correlation to gender with p =0,000 (Table 5.2.47). On average, female pupils scored a mean of 2,50 on this scale, and male students a mean of 2,13 (Table 5.2.45).

Table 5.2.48

Male Students

Future/Past	**Frequency**	**Percent**
Not understood	7	5,5
Failed to see effect	14	11,0
Vague answer	61	48,0
Specific reply	45	35,4
Total	127	100,0

Table 5.2.49

Female Students

Future/Past	Frequency	Percent
Not understood	1	0,6
Failed to see effect	17	9,5
Vague answer	53	29,6
Specific reply	108	60,3
Total	179	100,0

After evaluating temporal thinking, male pupils have the highest percentage at the value 2 by "Vague answer" with 48,0% (Table 5.2.48). In comparison, 60,3% of the female students gave a specific reply that employed retrospection and/or a look into the future (Table 5.2.49).

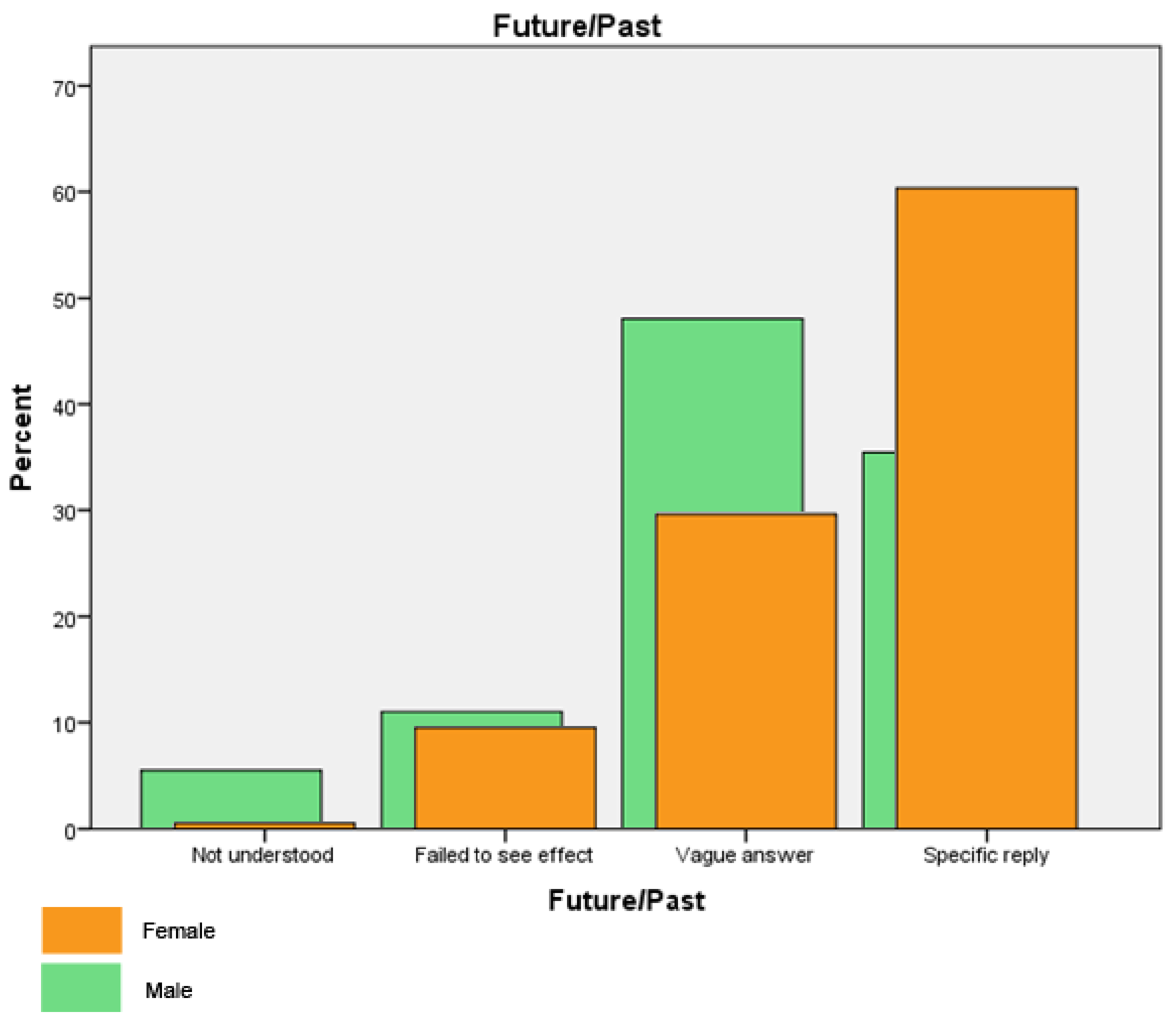


Image 5.2.10

In Image 5.2.10 it is apparent that both male and female participants most frequently offered replies including an application of temporal thinking. Males however tended toward vague answers while females were more specific in their replies.

I then grouped values 0 and 1 together, as well as values 2 and 3, so that „Not understood“ and „Failed to see effect“ were in one group and „Vague answer“ and „Specific reply“ in a second group. When only these two groups were analyzed for correlation to gender, nothing could be found. The percentage of students in each of these two groups was similar for either gender, as can be seen in Table 5.2.50 below, as well as Image 5.2.11.

Table 5.2.50

Future/Past

		Frequency	Percent
Female:	Not understood	18	10,1
	Vague or Specific Reply	161	89,9
	Total	179	100,0
Male:	Not understood	21	16,5
	Vague or Specific Reply	106	83,5
	Total	127	100,0

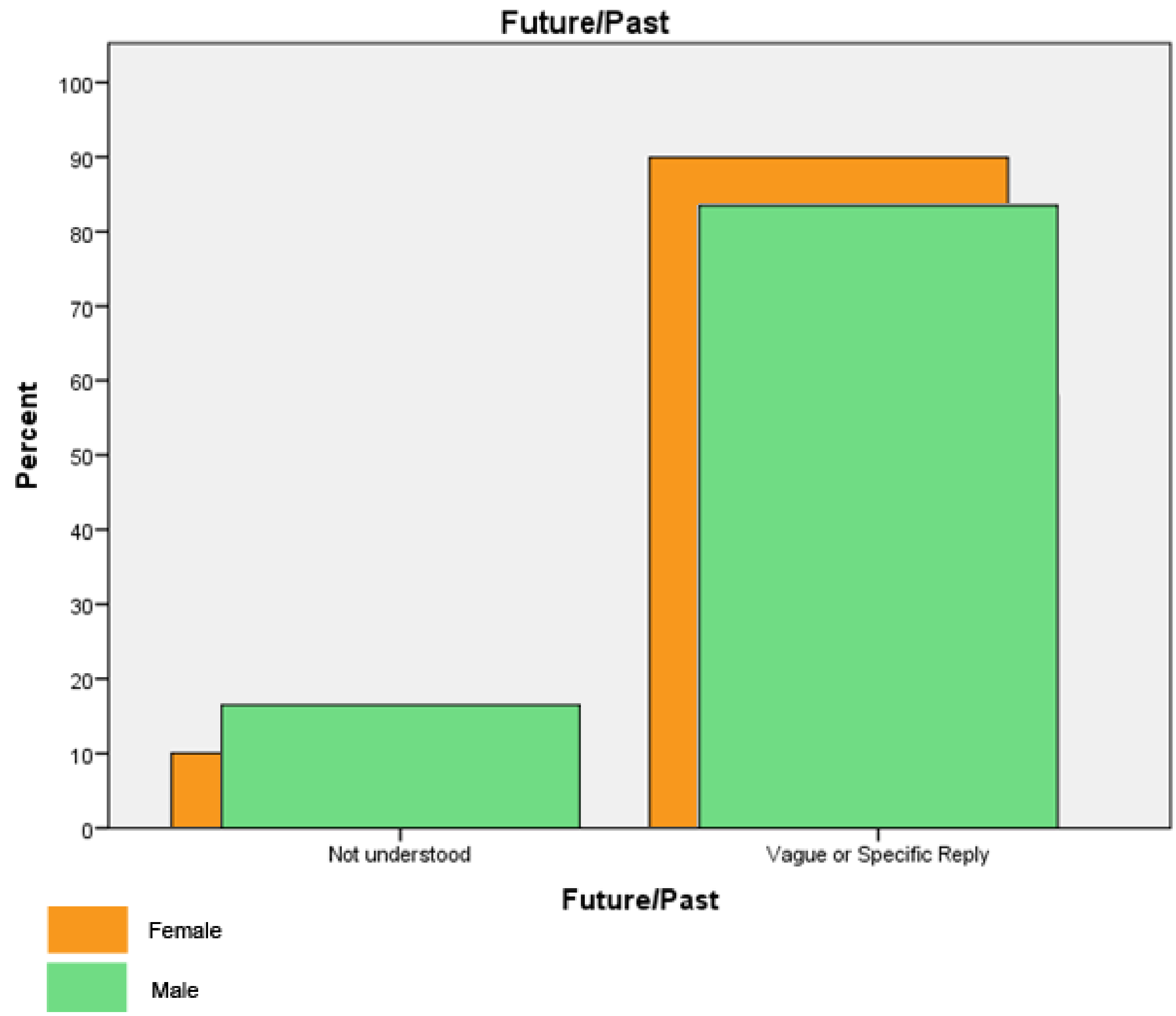


Image 5.2.11

5.2.2 Correlation to Age

Of the parameters tested against age for correlation, only two proved to be within the range of significance: amount of connections and amount of dynamic relationships.

Age to Connections

Table 5.2.51

Connections

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
15-16 years	165	20	4	24	10,92	3,293	10,846
17-19 years	118	17	4	21	10,18	3,006	9,036

Table 5.2.52

Connections	Age	N	Mean Rank	Rank Total
	16	165	150,29	24797,5
	17	118	130,41	15388,5
	Total	283		

Table 5.2.53

	Connections
Mann-Whitney-U	8367,5
Wilcoxon-W	15388,5
Z	-2,027
Asymptotic significance (2 sides)	0,043

Table 5.2.53 shows that with p=0,043 there is a significant correlation between age of the participant and amount of connections. Under the category “16”, students of the ages 15-16 were grouped, and under the category “17” students of the ages 17-19. The younger pupil group has a higher mean rank than the older group, and a higher amount of connections means a higher rank (Table 5.2.53). The mean average of the younger students is by 10,92 connections, that of the older students by 10,18 connections (Table 5.2.51).

Table 5.2.54

15-16 Years

Connections	Frequency	Percent
4	1	0,6
5	3	1,8
6	5	3,0
7	11	6,7
8	19	11,5
9	20	12,1
10	24	14,5
11	17	10,3
12	19	11,5
13	17	10,3
14	10	6,1
15	7	4,2
16	5	3,0
18	2	1,2
19	1	0,6
20	1	0,6
21	1	0,6
22	1	0,6
24	1	0,6
Total	165	100,0

Table 5.2.55

17-19 Years

Connections	Frequency	Percent
4	3	2,5
5	1	0,8
6	3	2,5
7	9	7,6
8	18	15,3
9	23	19,5
10	15	12,7
11	15	12,7
12	11	9,3
13	5	4,2
14	3	2,5
15	5	4,2
16	4	3,4
19	2	1,7
21	1	0,8
Total	118	100,0

Regarding the amount of connections with a percentage of over 10%, pupils of ages 15-16 find these at the amounts 8-13 connections, while pupils of ages 17-18 find these at 8-11 connections (Table 5.2.54 and 5.2.55). The highest frequency for participants aged 15-16 lies by 10 connections, for those of ages 17-19 it lies by 9 with almost 20%.

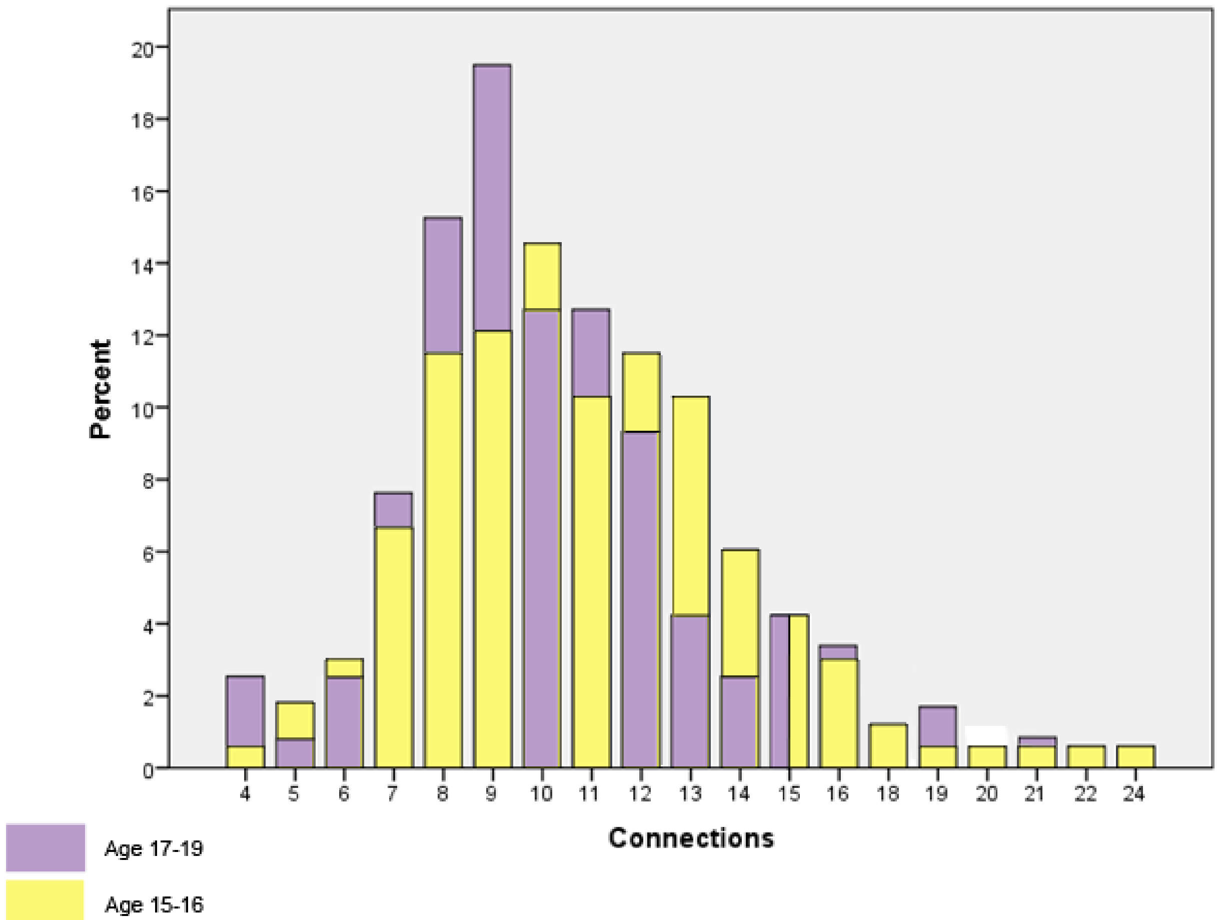


Image 5.2.12

Shown in Image 5.2.12, there is a slight shift of ages 15-16 toward higher amounts of connections in comparison to the age group 17-19. The range of 15-16 year olds is 20, and therefore a little bit higher than the range of 17 that the age group 17-19 years has, as also seen in Table 5.4. The amount of participants with 20 or more connections is minimal, however.

Age to Dynamic Relationships

Table 5.2.56

Dynamic Relationships

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
15-16 years	166	15	0	15	3,02	2,819	7,945
17-19 years	118	11	0	11	2,09	2,572	6,615

Table 5.2.57

Dynamic Rel.	Age	N	Mean Rank	Rank Total
	16	166	155,14	25752,5
	17	118	124,72	14717,5
	Total	284		

Table 5.2.58

	Dynamic Rel.
Mann-Whitney-U	7696,5
Wilcoxon-W	14717,5
Z	-3,132
Asymptotic significance (2 sides)	0,002

The Mann-Whitney-U test revealed a significant correlation of dynamic relationships to age with p =0,002, as seen in Table 5.2.58. As the participants aged 15-16 show a higher ranking than those aged 17-19 and 1 is the lowest possible rank, the higher amount of connections was employed by the younger group (Table 5.2.57). The mean of dynamic relationships employed by the younger pupils lies at 3,02, for the older pupils at 2,09 (Table 5.2.56).

Table 5.2.59

15-16 Years

Dynamic Rel.	Frequency	Percent
0	40	24,1
1	25	15,1
2	16	9,6
3	22	13,3
4	18	10,8
5	9	5,4
6	19	11,4
7	7	4,2
8	2	1,2
9	3	1,8
10	4	2,4
15	1	0,6
Total	165	100,0

Table 5.2.60

17-19 Years

Dynamic Rel.	Frequency	Percent
0	45	38,1
1	19	16,1
2	12	10,2
3	18	15,3
4	9	7,6
5	2	1,7
6	2	1,7
7	5	4,2
8	2	1,7
9	1	0,8
10	1	0,8
15	2	1,7
Total	118	100,0

As seen in Table 5.2.59 and 5.2.60, the type values with the highest frequency are 0 and 1 by both age groups, with 24,1% and 15,1% respectively for 15-16 years of age, and for the participants aged 17-19 with 38,1% and 16,1% respectively.

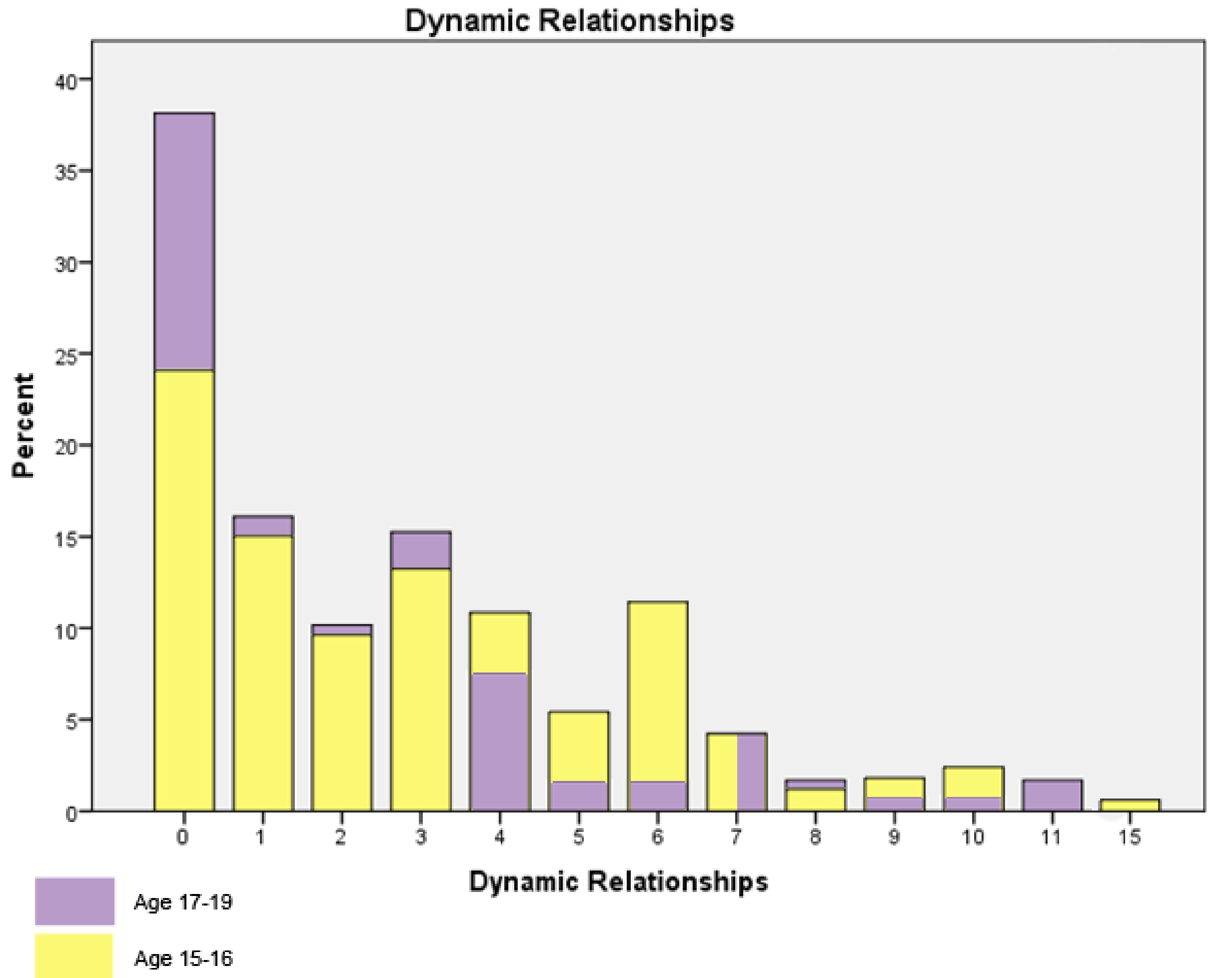


Image 5.2.13

Image 5.2.13 displays the emphasis of the older group of students on 0 dynamic relationships, which is also the value with the highest discrepancy between the two groups, at 14%. The younger group of students is more strongly present at the values 4-6, with a plus of 3,2-10,7%.

5.2.3 Correlation to Fluent Languages

Fluent Languages to Peer Contact

Of the parameters tested against fluent languages for correlation, only one proved to be within the range of significance: contact to peers outside of Austria. Instead of a Mann-Whitney-U test, a Chi test was used to determine significance of the correlations to the amount of languages spoken fluently.

Table 5.2.61

Contact Yes/No

Fluent Languages	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
1	21	1	1	2	1,67	0,483	0,233
2	147	1	1	2	1,59	0,494	0,244
3	109	1	1	2	1,39	0,489	0,239
4+	28	1	1	2	1,29	0,460	0,212

Table 5.2.62

Contact Yes/No	Languages	N	Mean Rank
	1	21	179,67
	2	147	167,22
	3	109	136,76
	4+	28	121,57
	Total	305	

Table 5.2.63

	Contact Yes/No
Chi-Squared	17,328
df	3
Asymptotic significance	0,001

The Chi test revealed a highly significant correlation to foreign contact with p =0,001 (Table 5.2.63). In this case, the question only required yes or no answers. If the participant had regular contact to peers outside of Austria, the reply “yes” was given the value 1. If the participant did not have regular contact to peers outside of Austria, the reply “no” was given the value 2.

In Table 5.2.62, it shows that the higher the amount of languages spoken fluently, the lower the rank, which means the more predominant the value 1 was applied. The higher the rank, the more predominant the value 2 among the data. The mean averages of each amount of fluent languages spoken also progressively decrease, with 1 language having a mean of 1,67, 2 languages of 1,59, 3 languages of 1,39 and 4 or more languages having a mean of 1,29 (Table 5.2.61).

Table 5.2.64

Fluent Languages: 1

Contact	Frequency	Percent
Yes	7	33,3
No	14	66,7
Total	21	100,0

Table 5.2.65

Fluent Languages: 2

Contact	Frequency	Percent
Yes	61	41,5
No	86	58,5
Total	147	100,0

Table 5.2.66

Fluent Languages: 3

Contact	Frequency	Percent
Yes	67	61,5
No	42	38,5
Total	109	100,0

Table 5.2.67

Fluent Languages: 4+

Contact	Frequency	Percent
Yes	20	71,4
No	8	28,6
Total	28	100,0

As seen in Table 5.2.64 through Table 5.2.67, the more languages are spoken fluently, the more the percentages shift from “No” to “Yes” in the question to frequent contact with peers outside of Austria.

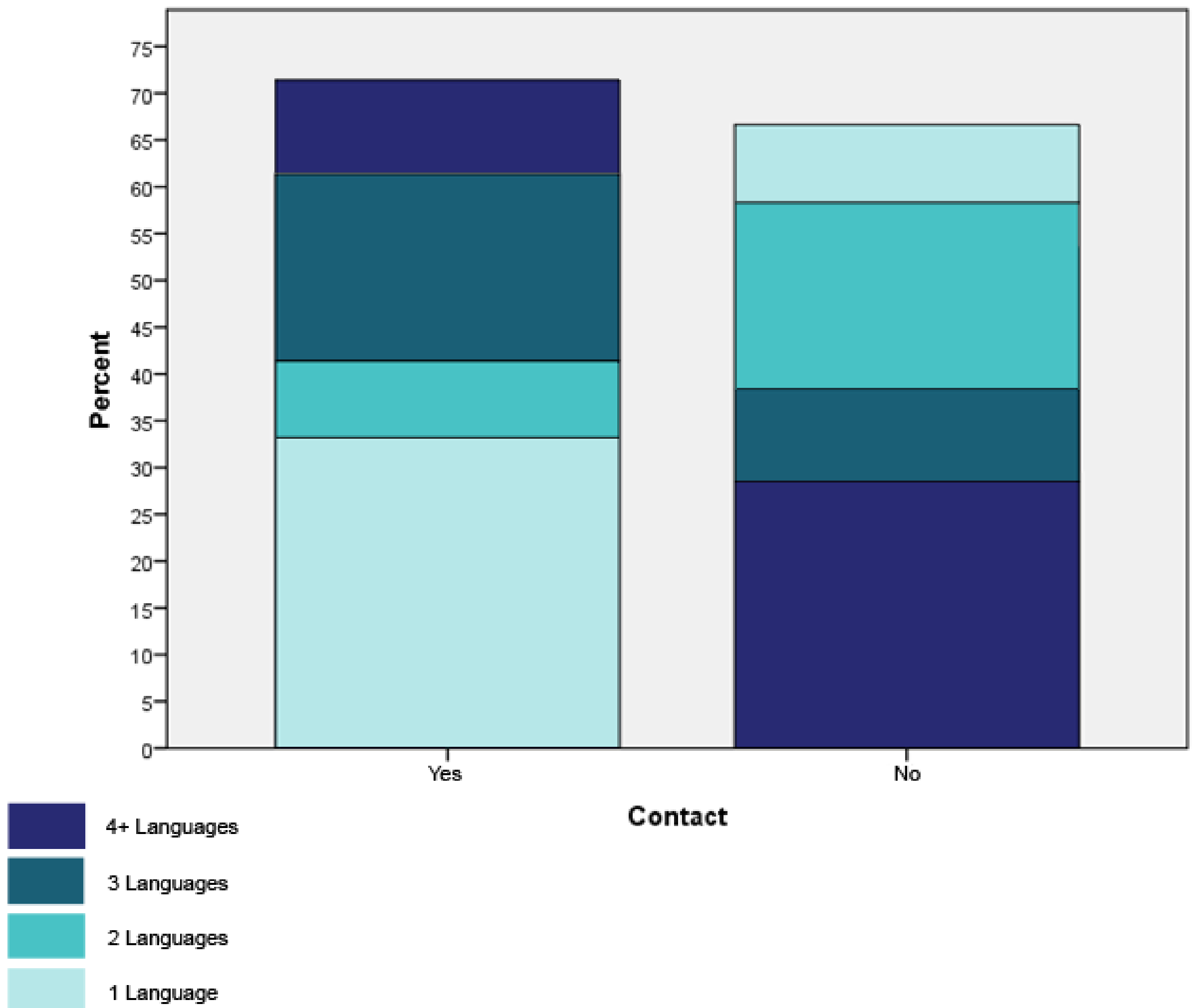


Image 5.2.14

In Image 5.2.14 the reversal of amount of fluently spoken languages between the students who do and who don’t regularly uphold contact to peers outside of Austria is apparent. In this image, the sum of “yes” and “no” percentages for each language separately equal 100%.

5.2.4 Correlation to Type of Gymnasium

With help of Mann-Whitney-U tests, correlation to the type of Gymnasium attended by the participants was determined. For this study, he two types of education – Gymnasium and Realgymnasium – are defined more clearly on page 31.

Type of Gymnasium to Future/Past

Table 5.2.68

Future/Past

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Realgymnasium	164	4	0	3	2,23	0,811	0,658
Gymnasium	142	4	0	3	2,48	0,692	0,478

Table 5.2.69

Future/Past	Type of Gymn.	N	Mean Rank	Rank Total
	Realgymnasium	164	141,65	23230
	Gymnasium	142	167,19	23741
	Total	306		

Table 5.2.70

	Future/Past
Mann-Whitney-U	9700
Wilcoxon-W	23230
Z	-2,777
Asymptotic significance (2 sides)	0,005

With p =0,005, the Mann-Whitney-U test revealed a highly significant correlation of Gymnasium type to the ability to think temporally (Table 5.2.70). For the open-response questions, the replies were evaluated as 0 = didn't understand the question, 1 = failed to see the effect, 2 = vague reply on the effect, 3 = detailed reply on the effect. As seen in Table 5.2.68, the mean average for students of a Realgymnasium was at 2,23 and for students of a Gymnasium at 2,48.

Table 5.2.71

Realgymnasium

Future/Past	Frequency	Percent
Not understood	6	3,7
Failed to see effect	21	12,8
Vague answer	66	40,2
Specific reply	71	43,3
Total	164	100,0

Table 5.2.72

Gymnasium

Future/Past	Frequency	Percent
Not understood	2	1,4
Failed to see effect	10	7,0
Vague answer	48	33,8
Specific reply	82	57,7
Total	142	100,0

As seen in Table 5.2.71, the highest frequency for participants attending a Realgymnasium is at Specific Reply with 43,3%, whereas for participants attending a Gymnasium the highest frequency is at 57,7% for Specific Reply (Table 5.2.72). Both the students of a Realgymnasium and of a Gymnasium least frequently didn’t understand the question, with 3,7%, and 1,4% respectively.

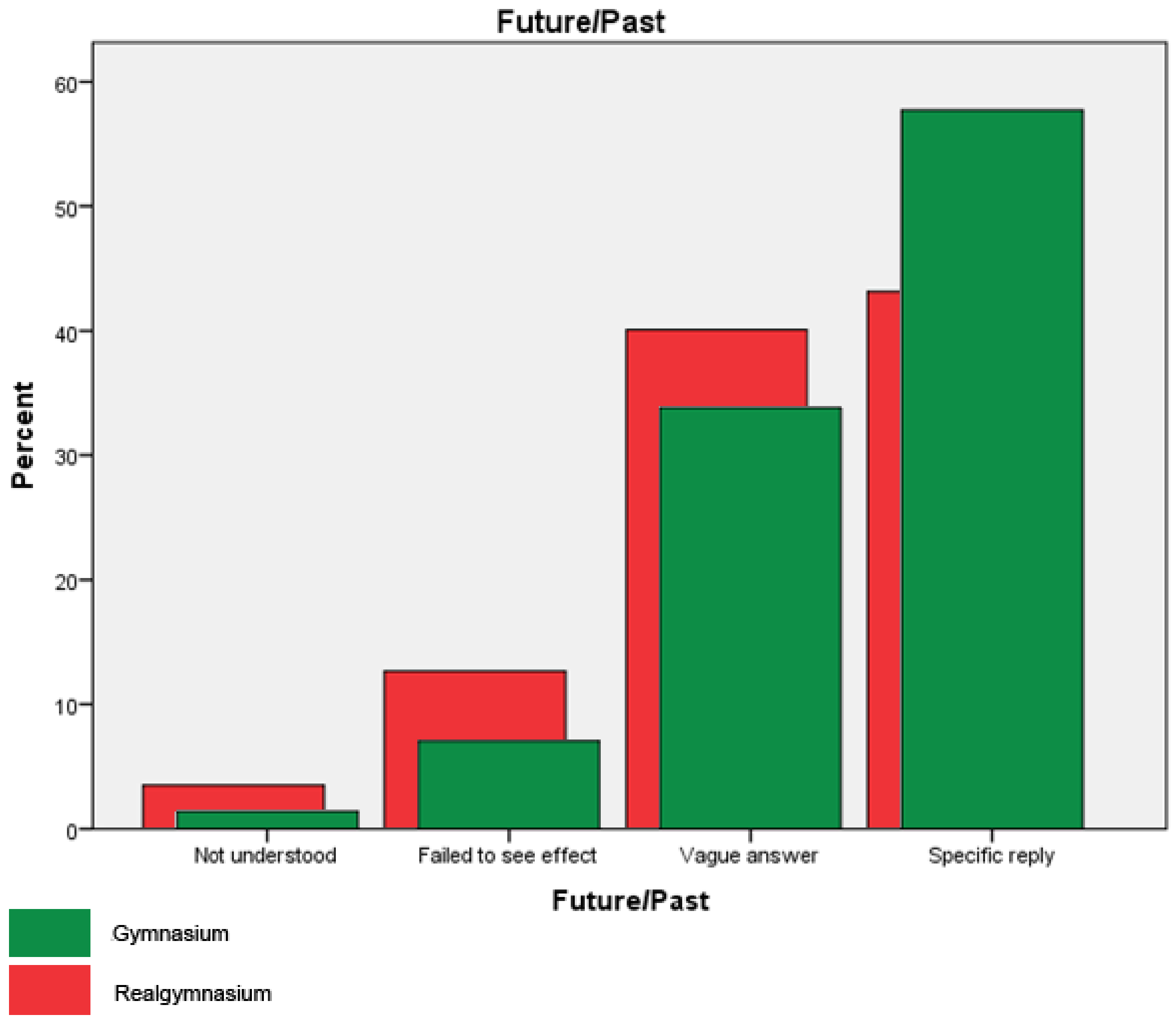


Image 5.2.15

Though Image 5.2.15 shows that students of both types of education have similar progression in frequency the more complex the reply, but with different slopes. The gradient for pupils attending a Gymnasium is steeper than those of the Realgymnasium.

6. Discussion

Why?

I would first like to start off with questions I was often asked by students as well as teachers throughout this study. Doesn't everybody already apply system thinking in their daily lives? If it's something we already do on instinct, why should there be need to teach or practice it in schools?

It is true, we as humans do naturally already try to analyze and understand systems as a whole from a very young age on. Nevertheless, our intuition or "gut feeling" can be easily deceived by phenomena such as time delay and hidden dimensions if we aren't accustomed to watch out for them. We are tempted to focus our attention on the elements and interactions that interest us, and tend to therefore neglect aspects that we find less relevant or less appealing. Lack of motivation or confidence lead us to take well-trodden roads we are comfortable on and that require less effort. I believe it is these kinds of processes which lie at the root of the correlations I have found in this study, and I believe that while these processes usually happen subconsciously, with practice and experience we can close the gaps that are presented here. If we became more conscious of our subconscious way of understanding the world around us, I feel it should be easier for us to adjust, correct and refine the intuition we rely on.

I think especially young adults would profit from having accumulated experience in dealing with complex problems before finishing school, as they will soon venture out into a jungle of interconnected systems for the first time on their own. I furthermore believe that with an enhanced awareness of system thinking approaches, we are able to not only understand the world around us better, but also the world inside us. Emotions, especially negative ones that have grown and gathered over time, are never simple and can't be deciphered with analytical methods. The cause of anger and disappointment can easily be attributed to the wrong events, and finding an appropriate solution or even avoiding a repetition of the situation becomes more difficult.

To me, the relevant question that arises from this study is not to what extent young people differ in their ability to think in systems, but how we can encourage them to do so more often and help them do it more consciously. In order to do that, I think it is helpful to examine the correlations found in this study, as they can serve as indicators for targets of improvement.

Where?

Firstly I will talk about the gender correlations found in this study, which is also the most prominently represented category. Male participants seemed to create more complex and interwoven concept maps than their female colleagues, as they on average had a higher percentage of C4+ elements, a higher average number of interactive connections, and more often designed a more complex type of concept map according to the hierarchy I had listed. In turn, female students on average introduced more new elements to the concept map than males, more often uncovered hidden dimensions, and received higher values for their generalization and temporal thinking ability in the open response questions. Unrelated to the concept map and open-response questions, gender correlations could also be found for age, amount of languages spoken fluently, and type of gymnasium visited.

I won't go far into the correlations unrelated to the concept map and open-response questions found, as they are subjects of discussion in themselves. Nevertheless, they help shape a better idea of the sample groups. The female participants are on average younger than males in this study, which is likely a reflection of girls being entered into the school system earlier than boys, and girls being less likely to repeat a grade than boys, as observed in studies such as by Schwarz-Jung (2010). In that same study it is furthermore discussed why more girls than boys in general attend a gymnasium, as the unequal amount of male and female pupils in the sample of my study also appears to reflect.

Male students are found to more commonly attend a Realgymnasium, focusing on science, mathematics or economy while female students are found to more frequently attend a Gymnasium, focusing on ancient or modern languages. This can be explained by the difference in interests, motivation, achievement and self-image between boys and girls as found in the study of Suchań et al. in 2010. With more female than male students attending a Gymnasium focusing on languages, and with females on average having a higher affinity for languages in general (EACEA, 2009), it doesn't come as a surprise that they scored a higher average than males for languages spoken fluently.

With these factors in mind, the correlations regarding the concept map and system thinking skills can already be partially explained. Male students more frequently attend a school that teaches more scientific, methodical approaches to problems posed in a test while female students more often attend schools where test questions more often focus on elaborate answers and essays. Therefore one can argue this background to be part of the cause for girls averaging better on the aspects of system thinking that are connected to expression, and boys averaging better on the aspects connected to method. Nevertheless, one can also argue that the difference is biologically inherent, as boys and girls choose these different education types due to their different abilities, motivations, interests and self-image. With the gender question being a chicken-or-the-egg situation, it is interesting to compare findings of studies focusing on adults. The gender difference in the system thinking skills tested by Capelo and Dias (2005) is still there, but was assumed to diminish with age and experience, until no significant difference can be found.

As it is indicated males and females assimilate later in their education, is the gender difference noted here due to different inherent abilities or due to learning experience? Most people like to use the simplest paths with the least effort, which usually also is the most familiar to them. I don't think it is unlikely that students employed the strategies they are accustomed to employing on school exams. Especially on the open-response questions several students directly contradicted themselves in their answers of one question to that of another, although they were essentially the same question with a different phrasing (question 2 and 3, see Appendix). To me, this indicates a strategy of trying to get at least one of the answers "right" when the correct answer appears unpredictable to the person taking the test.

When assuming that the results of the study reflect the different tools female and male students have become familiar to adopt when taking exams, then the question of whether the cause is inherent ability or learning experience seems of less relevance to me. What I find more important is the acknowledgement of a difference, and the acknowledgement that the gap can be closed and tools can be honed if system thinking becomes a more integral part of the educational plan.

The second parameter which has been found to correlate to system thinking skills is age. I had grouped 15 and 16-year olds together and compared them to the students 17 and older. The younger group on average employed a higher amount of connections between elements, and also inserted a higher amount of dynamic relationships. With the younger group scoring higher on average, this could contradict the idea of experience positively influencing system thinking skills. Nevertheless, the older age group did not have a significantly higher amount of previous experience with concept maps. The older group of students includes those who have repeated a year of school or more, and it would be interesting to examine more closely if there is a link between academic achievement and the ability to make connections and recognize dynamic relationships, as the only significant difference between the age groups seem to both be related to defining relationships between elements.

Another interesting parameter to examine for correlation is the type of gymnasium attended by the students. Only in one aspect did there appear to be a difference in the application of system thinking skills, regarding temporal thinking. Pupils of a Gymnasium scored a higher average than pupils of a Realgymnasium in this regard. As this was one of the open-response questions, it ties in to the gender correlation with temporal thinking as well, since the type of school was correlated to gender too. The difference could be explained by the open-response question having more appeal on students of a Gymnasium than of a Realgymnasium and therefore they invested more time and effort in it, or by students of a Gymnasium being more practiced in answering such a question.

The last parameter of amount of fluent languages spoken being correlated to amount of contact to peers outside of Austria isn’t surprising, as this group would include people with multi-lingual backgrounds, with family and friends in different parts of the world.

It is interesting to note that previous experience with concept maps had no significant impact on the results of this study. This could be explained by a differing personal interpretation of “previous experience” by each student, or by confusing concept maps with mind maps and similar tools used more frequently in class. I furthermore did not find a correlation between amount of languages spoken fluently and contact to peers outside of Austria to any of the system thinking skills. The parameters might have been unsuited for representing students connected to or interested in multiple cultures, or perhaps the confrontation of different viewpoints between cultures doesn’t impact the way students think in systems.

How?

While in the grand scheme of things it isn't very relevant how much effort a 16-year old student invests in the creation of a concept map of a voluntary study, it can have a much greater impact on our society if policy makers don't invest the necessary time and thought, or simply never learned to confront complex problems with a systems approach. Practice, experience, deliberate confrontation with the methods and procedures of system thinking and system dynamics should improve so that vague notions of intuition can be honed and translated into maps of dynamic systems and holistic problem solving approaches.

In subjects like biology, politics or economy it is likely that a system approach is already part of the course material. A direct way to help practice system thinking more in school would be to apply this kind of system approach to other subjects as well, like examining characters of a novel in English class or the process of a revolution in History with a system thinking method.

Another possible way to enhance system thinking by students is to synchronize and network school subjects more often. Math, science, history, music, languages and literature have always shaped each other over the centuries, and none of them developed independent of the others. Each of these fields influence the way we think, feel and communicate, as individuals, as a society and as nations. Perhaps students can be encouraged to think about what changed in all of those subjects when the printing press was invented? What historic events caused the boom of natural sciences and what impact did it have on the literature at the time, and how did this in turn shape history? Can the influences of the invention of the printing press be compared to the rise of the internet?

I believe it would be helpful for students to see just how the world around them is interwoven, how everything we have today stems from the past and will continue to develop in the future. These kinds of questions however should not just be asked in history or any single subject, but across all subjects, each taking the approach relevant to their content material. With both improved confidence and experience in a system thinking approach, I believe the curiosity to connect can be awakened in students, and they could be more motivated to think about current complex problems that are affecting the world we live in.

7. Index

Ackoff, R. L. (1998): *A Systemic View of Transformational Leadership*. Journal of Systemic Practice and Action Research, 11(1), pp. 23-36. Springer, Netherlands.

Assaraf, O., Orion, N. (2005): *Development of System Thinking Skills in the Context of Earth System Education*. Journal of Research in Science Teaching, 42(5), pp. 518-560.

Bateson, Gregory (1972): *Steps to an Ecology of Mind: Collected Essays in Anthropology, Psychiatry, Evolution, and Epistemology*. University Of Chicago Press.

von Bertalanffy, L. (1968): *General System Theory: Foundations, Developments, Applications.* rev. ed. New York: George Braziller.

Betts, F. (1992): *Improving School Quality: How Systems Thinking Applies to Education.* Educational Leadership (Volume 50, Number 3).

Sweeney, L. B. (2001): *When a Butterfly Sneezes: A Guide for Helping Kids Explore Interconnections in Our World Through Favourite Stories*. USE: Pegasus.

Boulding, K. E. (1956): *General Systems Theory: the Skeleton of Science*. Management Science, pp. 197-208.

Campbell, D. T. (1969): *Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience*. Interdisciplinary Relationships in the Social Sciences, pp. 328-348, ed. M. Sherif. Chicago: Aldine.

Capelo, C., Dias J. F. (2005): *Strategy Lab Experiences: Bathtub Dynamics.* ADETTI/ISCTE, Portugal.

Checkland, P. B. (1981): *Systems Thinking, Systems Practice*, John Wiley, Chichester.

DMI: *About Donella Meadows*. Donella Meadows Institute. DOR: 02.02.12 <http://www.donellameadows.org/donella-meadows-archive/about-donella-meadows/>

Dopfer, K. (1994): *Kenneth Boulding: A Founder of the Systems Sciences and of Evolutionary Economics*. Journal of Economic Issues, 28(4), (revised) pp. 1201-04 DOR: 08.03.12 <http://projects.isss.org/Kenneth_Boulding>

Draper, F. (1991): *Integrating Systems Thinking and Simulation into the Eighth Grade Science Curriculum*. Creative Learning Exchange.

EACEA; Eurydice. (2009): *Geschlechterunterschiede bei Bildungsresultaten: Derzeitige Situation und aktuelle Maßnahmen in Europa.* Brussels: Eurydice. ISBN 978-92-9201-079-9.

Evagorou, M. et al., (2008): *An Investigation of the Potential of Interactive Simulations for Developing System Thinking Skills in Elementary School: A case study with fifth-graders and sixth-graders.* International Journal of Science Education, 99999(1), pp.1-20. DOR: 03.05.2011 <http://www.informaworld.com/10.1080/09500690701749313>

Forrester, J. W. (1992): *System Dynamics and Learner-Centered-Learning in Kindergarten Through 12th Grade Education*. Technical Report D-4337, MIT.

Forrester, J. W. (2009): *Learning through System Dynamics as Preparation for the 21st Century.* Systems Thinking and Dynamic Modeling Conference for K-12 Education, Concord Academy, Concord, MA, Sloan School of Management, Massachusetts Institute of Technology (1994; revised 2009).

Forrester, J. W. (2010): *System Dynamics: the Foundation Under Systems Thinking*, Sloan School of Management, Massachusetts Institute of Technology, Cambridge, MA.

GLOBE. (2005): *The Next Generation Globe*. GLOBE Program: Boulder, CO. DOR: 05.04.2011 <http://globe.gov/about/vision>

Haken, H. (2007): *Synergetics*. Scholarpedia, 2(1):1400, revision #87434. DOR: 29.02.2012 <http://www.scholarpedia.org/article/Synergetics>

Hlawatsch, S., et al. (2005): *Forschungsdialog: System Erde - Schlussbericht* - IPN Leibniz-Institute, Kiel: Christian-Albrechts-Universität zu Kiel.

Hmelo, C., Holton, D., Kolodner, J. (2000): *Designing to Learn About Complex Systems.* The Journal of the Learning Sciences, 9 (3), 247-298.

Hmelo-Silver, C. E., Pfeffer, M. G. (2004): *Comparing Expert and Novice Understanding of a Complex System From the Perspective of Structures, Behaviours, and Functions.* Cognitive Science, 28, pp. 127–138.

Jacobson, M. J. (2001): *Problem Solving, Cognition, and Complex Systems: Differences Between Experts and Novices.* Complexity, 6(3), pp. 4-49.

Jacobson, M., Wilensky, U. (2006): *Complex Systems in Education: Scientific and Education Importance and Implications for the Learning Sciences*. The Journal of the Learning Sciences, 15(1), pp. 11-34.

Kasperidus H-D., Langfelder H., Biber P. (2006): *Comparing systems thinking inventory task performance in German classrooms at high school and university level.* In Proceedings of the 24th International Conference of the System Dynamics Society. Nijmegen, Netherlands.

Kien-Kheng, F., et al. (2006): *Systems-thinking skills exhibited by UiTM Sarawak diploma students in solving problems.* Institut Penyelidikan, Pembangunan Dan Pengkomersilan: Universiti Teknologi Mara.

LUMS: *Professor Peter Checkland*, Lancaster University Management School. DOR: 02.02.2012 <http://www.lums.lancs.ac.uk/profiles/peter-checkland/>

Lecher, T. (1997): *Die Umweltkrise im Alltagsdenken*. Weinheim: Beltz.

Liddell, H. G., Scott, R. (1940): *A Greek-English Lexicon*. Revised and augmented throughout by Sir Henry Stuart Jones with the assistance of Roderick McKenzie. Oxford. Clarendon Press.

Lyneis D. A. (2000): *Bringing System Dynamics To A School Near You Suggestions For Introducing And Sustaining System Dynamics In K-12 Education,* International System Dynamics Society Conference Bergen, Norway.

Lyneis, D. A., Fox-Melanson, D. (2001): *The Challenge of Infusing System Dynamics into a K-8 Curriculum,* the 19th International System Dynamics Society Conference. Atlanta, Georgia.

Malik, F.: *Ecopolicyade – Vernetztes Denken im Wettbewerb*, DOR: 05.04.2011 <http://www.ecopolicyade.info/>

Meadows, D., et al. (1972): *Limits to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind.* New York.

Meadows, D. (2008): *Thinking in Systems – A Primer*. Chelsea Green Publishing.

O'Hara, M. T., O'Hara, J. A. (1998): *Corporation Learning: A Paradigm for Learning in the 21st Century*. American Secondary Education 27, pp. 9-17.

Ossimitz, G. (2000): *Entwicklung systemischen Denkens*. München: Profil Verlag. ISBN 3-89019-494-X

Ossimitz, G., Kainz, D. (2002): *Can Students Learn Stock-Flow-Thinking? An Empirical Investigation.* Paper submitted to the 2002 System Dynamics Conference, Palermo, Italy.

Plate, R. R. (2006): *Assessing the Effectiveness of Systems-Oriented Instruction for Preparing Students to Understand Complexity*, Doctorate Dissertation University of Florida.

Rapoport, A., Chammah, A. (1965): *Prisoner's Dilemma*, The University of Michigan, Ann Arbor, MI.

Resnick, M. (1996): *Beyond the Centralized Mindset*. Journal of the Learning Sciences, 5, pp. 1-22.

Sheatsley, N. D. (1996): *A Biography of Rapoport*. DOR: 19.12.2011 <http://www.gwu.edu/~asc/people/Rapoport/rapoport.html>

Schwaninger, M. (1998): *Anatol Rapoport (*1911)*, International Society for the System Sciences. DOR: 19.12.2011 <http://www.isss.org/lumrapo.htm>

Schwanitz, D. (1995): *Systems Theory According to Niklas Luhmann: Its Environment and Conceptual Strategies.* Cultural Critique; No. 30. The Politics of Systems and Environments, Part I (Spring, 1995), pp. 137-170. University of Minnesota Press. DOR: 28.02.2012 <http://www.jstor.org/stable/1354435>

Schwarz-Jung, S. (2010): *Mädchen und Jungen im Spiegel der Schulstatistik.* Statistisches Monatsheft Badenwürttemberg 6/2010.

Senge, P. M. (1990): *The Fifth Discipline: the Art and Practice of the Learning Organization*. New York: Doubleday.

Sommer, C. (2005): *Untersuchung der Systemkompetenz von Grundschülern im Bereich Biologie.* Kiel: Christian-Albrechts-Universität zu Kiel.

Steinberg, A. (1997): *From School to Work: Making the Transition*. Current: pp. 9-12.

Strong, M. (2001): Foreword in *Human Ecology*. Marten, Gerald, Ed. Earthscan: Sterling, VA.

Suchań et al. (2010): *TIMSS 2007. Mathematik & Naturwissenschaft in der Grundschule. Österreichischer Expertenbericht*. Graz: Leykam. DOR: 03.03.2012 <https://www.bifie.at/buch/1191>

Sweeney, L. B. & Sterman, J.D. (2000): *Bathtub Dynamics: Initial Results of a System Thinking Inventory*. System Dynamics Review, 16 (4), pp. 249-286.

The Institute for Intercultural Studies (2011): DOR: 29.07.2011 <http://www.interculturalstudies.org/Bateson/index.html>

United Nations. (2002): *No Sustainable Development without Education*. Unesco Press: Paris. DOR: 21.04.2011 <http://portal.unesco.org/en/ev.php-URL_ID=5751&URL_DO=DO_TOPIC&URL_SECTION=201.html.>

Walonick, D. S. (1993): *General Systems Theory.* DOR: 18.07.2011 <http://www.statpac.org/walonick/systems-theory.htm>

Wilhelm Hamiti, S., et al. (2010): *Systemdenken fördern – Systemtraining und Unterrichtsreihen zum vernetzten Denken*. Schulverlag Plus, ISBN-10:3-292-00628-7.

8. Appendix

8.1 Student Test (German original)

Name (bleibt anonym!):
____

Alter:
____

Geschlecht: weiblich / männlich

Klasse:
____

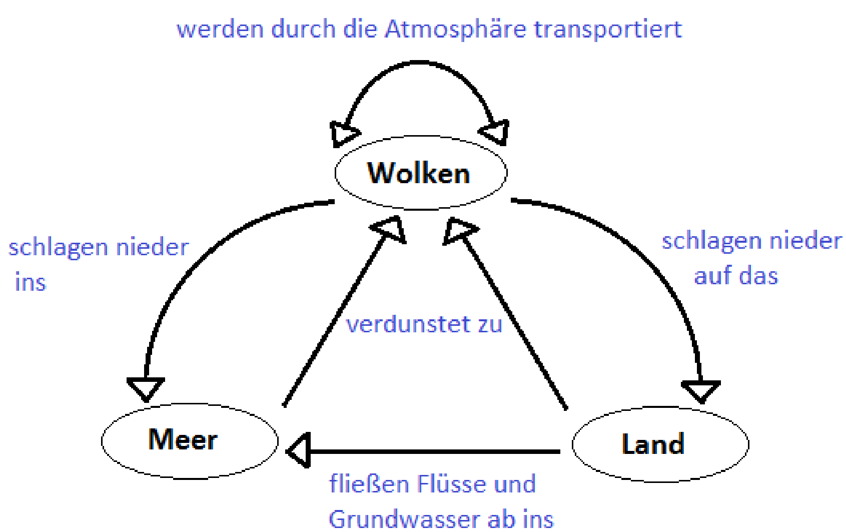
Erfahrung mit Concept Maps? Ja / Nein

Anzahl fließend beherrschter Sprachen: 1 2 3 4+

Hast du regelmäßigen Kontakt zu Gleichaltrigen, die nicht in Österreich leben? Ja / Nein

Eine **Concept-Map** ist die graphische Darstellung von Wissen und damit ein Mittel der Gedankenordnung. Sie besteht aus Elementen, welche mit Pfeilen verbunden werden. Die Pfeile werden so beschriftet, dass sich die verbundene Einheit in etwa als Satz lesen lässt.

Beispiel:



Aufgabe: Als SchülerIn ist einem Stress nichts Unbekanntes. Erstelle eine Concept Map zum Thema Alltagsstress eines Schülers/einer Schülerin unter Verwendung mindestens folgender Elemente. Fallen dir mehr ein, darfst du sie sehr gerne hinzufügen:

Stress, SchülerIn, Schule, Eltern, Schulnoten, Prüfungen, Freunde, Freizeit

Frage 1: Was würde sich ändern, wenn das Element „Prüfungen“ aus dem System wegfallen würde?

Frage 2: Trifft deine Concept Map auf jeden beliebige(n) SchülerIn deines Jahrgangs zu? Warum?

Frage 3: Trifft deine Concept Map auch auf eine(n) VolksschülerIn oder MaturantIn zu? Warum?

8.2 Student Test (English translation)

Name (remains anonymous!):
____

Age:
____

Sex: female / male

Grade:
____

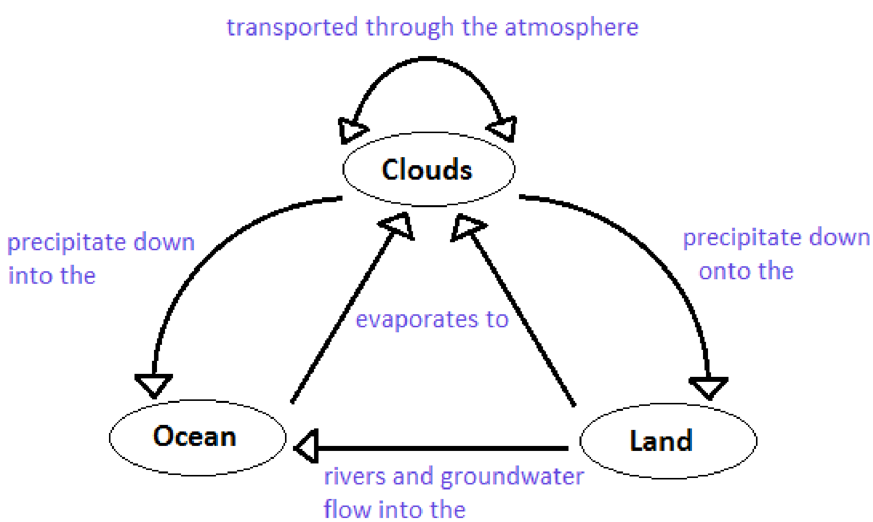
Experience with Concept Maps? Yes / No

Number of languages spoken fluently: 1 2 3 4+

Do you have regular contact with peers who do not live in Austria? Yes / No

A **Concept Map** is the graphical representation of knowledge and thus a means to organize thoughts. It is composed of elements which are connected by arrows. The arrows are labeled in such way that the connected units can be read in rough like sentence.

Example:



Task: As a student, stress isn't unfamiliar to you. Create a concept map about daily stress of a student using at least the following elements. If you can think of more yourself, please feel free to add them:

stress, student, school, parents, exam grades, exams, friends, leisure

Question 1: What would change if the element „exams" is removed from the system?

Question 2: Does your concept map apply to every student in your year? Why?

Question 3: Does your concept map apply to elementary school students or graduating students? Why?

8.3 Summary

The ability to think in systems becomes increasingly important as the global problems our society face become more complex. In order to assure sustainable solutions to these problems, our future generations should possess the ability to not only analyze a situation by examining the components, but to approach the system as a whole. In this study, the system thinking skills and competence of 11th grade students of around sixteen to seventeen years of age in various gymnasiums in Vienna are assessed and compared. This age group was selected because teenagers are in the learning process of making decisions about their lives for themselves and still in the process of discovering problem-solving strategies. I wanted to examine to what extent system thinking is employed in problem solving at this point in life. The students were given the task to draw a concept map for a specific systemic situation (“everyday stress of a student”) that all participants should be able to relate to without having studied it in class. The students were furthermore asked to answer open questions to assess their system thinking skills. The study aims to explore correlations with parameters such as gender, age, fluent languages spoken and contact to peers abroad to see if different circumstances within the same grade and different amount of cross-cultural exposure might have an impact on the results. The study was conducted in 12 schools with a total of 308 students over the month of December 2011. The study finds a gender difference in system thinking skills in several aspects, as well as a correlation to age and type of gymnasium. A link between system thinking skills and fluent languages spoken or contact to foreign peers could not be found. The ability and practice to think in systems still requires research especially among young people, and this study hopes to contribute to the understanding and promotion of system thinking in the education system of Austria.

8.4 Zusammenfassung

Die Fähigkeit, in Systemen zu denken gewinnt zunehmend an Bedeutung, je komplexer die globalen Probleme werden, die unsere Gesellschaft sich stellen muss. Um nachhaltige Lösungen für diese Probleme zu gewährleisten, sollten unsere zukünftigen Generationen die Fähigkeit besitzen, nicht nur eine Situation durch die Untersuchung der Komponenten zu analysieren, sondern auch sich dem System als Ganzes zu nähern. In dieser Studie werden die Fähigkeiten und Kompetenzen des Systemdenkens von ca. 16-17 jährigen SchülerInnen der 11. Schulstufe in verschiedenen Gymnasien Wiens überprüft und verglichen. Diese Altersgruppe wurde gewählt, weil Jugendliche sich im Lernprozess befinden, selbstständig Entscheidungen in ihrem Leben zu treffen und noch ihre Strategien zur Problemlösung am Entwickeln sind. Ich wollte untersuchen, inwieweit Systemdenken bei dieser Problemlösung angewendet wird. Die SchülerInnen hatten die Aufgabe, eine Concept Map für eine spezifische systemische Situation (Alltagsstress eines Schülers/einer Schülerin) zu entwerfen, bei der alle Beteiligten in der Lage sein sollten, ohne Vorkenntnisse sich damit gleichermaßen zu befassen. Die SchülerInnen wurden außerdem aufgefordert, offene Fragen zu beantworten, um ihr systemisches Denkvermögen genauer zu erfassen. Die Studie zielt darauf ab, Zusammenhänge mit Parametern wie Geschlecht, Alter, Anzahl fließend gesprochenen Sprachen und Kontakt zu Gleichaltrigen im Ausland zu erforschen. Außerdem wird überprüft, ob verschiedene Umstände innerhalb der gleichen Schulstufe und unterschiedliches Ausmaß an interkulturellen Austausch Gleichaltriger einen Einfluss auf die Ergebnisse haben könnten. Die Studie wurde in 12 Schulen mit insgesamt 308 SchülerInnen im Dezember 2011 durchgeführt. Es zeigt sich einen Geschlechterunterschied in verschiedenen Aspekten des Systemdenkens, sowie eine Korrelation zu Alter und Gymnasium. Einen Zusammenhang zwischen Systemdenken und Anzahl fließend gesprochener Sprachen oder Kontakt zu gleichaltrigen Jugendlichen außerhalb Österreichs wurde nicht festgestellt. Die Fähigkeit und Übung im systemischen Denken bedarf weiterer Forschung besonders in Bezug auf Jugendliche. Diese Studie hofft einen Beitrag zum Verständnis und zur Förderung des Systemdenkens im österreichischen Bildungssystem zu bieten.

8.5 Curriculum vitae

Name:	Julia Rose
Date and Place of Birth:	24.03.1987 in Assen, the Netherlands
Nationality:	Austria

Education:

Since October 2006	Study of Biology at the University of Vienna Specialization: Human Ecology Completed the first segment on schedule
1999-2006	German International School of The Hague Degree: Graduation (Abitur) with distinction (1,1)
April 2002	2-week practical training at a design and advertising agency
1997-1999	The Village School in Houston, Texas
1994-1997	German International School of The Hague, the Netherlands
1991-1994	English private school in Muscat, Sultanate of Oman

Linguistic Proficiency:	German: Native speaker English: Almost native speaker Dutch: Good qualification French: Basic skills Intermediate Latinum

8.6 Eidesstattliche Erklärung

Ich erkläre hiermit an Eides Statt, dass ich die vorliegende Arbeit selbständig und ohne Benutzung anderer als der angegebenen Hilfsmittel angefertigt habe.

Die aus fremden Quellen direkt oder indirekt übernommenen Gedanken sind als solche kenntlich gemacht.

Die Arbeit wurde bisher in gleicher oder ähnlicher Form keiner anderen Prüfungsbehörde vorgelegt und auch noch nicht veröffentlicht.

Wien, am 17.10.2012

Unterschrift
(Julia Rose)