Chapter 13
Promoting Abduction – A Teaching Experiment on Creative Learning Processes in a High School Classroom Context

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Abstract This paper draws on a recent study of teaching experiments in a Danish gymnasium (upper secondary school) context. The aim of the study was to afford students time to devise creative solutions to specific problems in each subject area. For the purposes of the study, abductive reasoning, applied to ordinary subjects in the classroom in a high school context, was seen as a driver of creativity. This rather conservative approach to teaching creativity at secondary school level can be contrasted with more radical, reform-oriented traditions within the field of creative education. The paper discusses the advantages of the conservative teaching approach in relation to promoting students' creativity in an upper secondary school context.

13.1 Introduction: New Demands – New Educational Contexts

The debate on education policy has for decades been based on the premise that complexity has increased in the late modern period (Hobel, 2012). It has been put forward that choices are no longer as simple and that the individual therefore has to be able to handle increasing amounts of information, opportunities, risks, etc. Sociologists have described late modern society using terms such as uncertainty, risk (Beck, 1992), reflexivity, workability, individualisation (Ziehe, 1989), globalisation, loss of tradition, and multiplicity of choices (Giddens, 1991). The debate on schools and education has taken this to mean that we can no longer simply develop pupils' convergent thinking but must also develop their skills with respect to handling new opportunities and challenges. The need for new skills has been understood in two ways. Firstly, such skills are linked to *personal* development and

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maturity, and secondly to the individual's future in a changing workplace environment (Hermann, 2003; Telhaug, 1994).

It was within this context that work on the reform of the Danish gymnasium was initiated in the late 1990s, leading in 2005 to, among other things, the decision to include the teaching of creative and innovative skills as educational goals in the preamble. One reason for the decision was the belief that the twenty-first century presents a different set of challenges and new circumstances for those entering the job market. The traditional career path, whereby the employee would gradually climb a 'ladder' towards a more senior position in a large organization, is a thing of the past (Keogh & Galloway, 2006; Matlay, 2011). Today many new jobs are created by small organizations and start-ups, who expect their employees to be adaptable, flexible and to form self-directed relational working teams (Duval-Couetil, 2013; Ouimet & Zarutskie, 2014). Rapid changes in the business world have emphasised the need for the individual to be able to continually learn, adapt, interact and create their own new opportunities. Education should therefore facilitate the acquisition of these abilities (Zhou & Hoever, 2014).

This paper has grown from a PhD project, which attempted to develop and explore the possibilities of an educational approach that reinforces *creative* skills in pupils through day-to-day teaching in the upper secondary school system. Building on this study, this chapter will try to answer a series of related questions. These are primarily questions such as: How should we define creativity in the context of the upper secondary school? Is it possible to identify characteristics of educational and teaching principles, covering all subjects and contexts, that could reinforce creative skills without compromising educational content?

13.2 Creativity in a Danish High School Context

Although much has been said and written about creativity in schools and in education generally, several questions have not been answered fully. There are three reasons for this, which are particularly evident in the case of Danish schools. *First*, current research and development efforts focus on strengthening creative skills through teaching principles and methods that do not pay particular attention to the specific context, for instance, the subject or discipline being taught (see Jensen & Kromann-Andersen, 2009). *Second*, existing research and current development work seldom take place in a typical institutional framework in a gymnasium (with respect to the individual subject or lesson) but are more likely to work within an exceptional framework – such as cross-discipline project weeks, 24-h camps etc., so that the above questions are not even on the agenda (see Hansen & Byrge, 2010). *Third*, existing research and current development work typically treat creativity in a mercantile sense, as a means to developing new (marketable) products, rather than seeing creativity in relation to the subject and as a function of understanding subject-related aspects, topics, etc. Existing research and development efforts often carry a

hidden agenda, with ambitions to *radicalise* significant aspects of the education system's goals and framework, or at least to *modify* them.

An example of the former ambition – *radical reform* – can be found in the conclusions of the respected British think tank, Demos (Seltzer & Bentley, 1999), according to which there is an urgent need for radical change in education in the West – from primary school to university – if we are to equip children and young people for the creative society of the future. Demos strongly criticises the way in which the education system in Western countries is organized – with class teaching, exams and the teacher's monopoly on teaching, etc. It outlines a new pedagogical model for the creative school of the future, in which the fixed curriculum is cut in half and pupils learn through projects that are developed in close cooperation with companies, organizations and local contacts.

The research project on which this chapter is based does not entertain such ambitions for radical change, for reasons which will be explained in the next section.

13.3 General Challenges in the Danish Context

The preamble listing goals for the four types of secondary education states that courses must "*develop the creative and innovative ability of pupils*" (Danish Act on Danish Act on Secondary Education, 2010:Article 2, Clause 4). The preamble does not contain more detailed instructions on the interpretation of creativity (or innovation) in secondary schools, nor does it mention which educational principles may be applied in order to strengthen pupils' creative skills. The *teaching plans* for individual subjects also fail to elucidate how these terms should be understood and/or applied. Nor are there conventions or guidelines to help teachers assess pupils' creative skills through various examinations in the gymnasium. This means that, to a significant extent, it is up to teachers and school directors to decide what creativity means and how one should approach teaching with a view to nurturing creative skills on a day-to-day basis. The fact that the requirement has been laid down in such a fashion means that practitioners have to apply themselves to interpretation; this can make the transition from statutory requirement to practical implementation somewhat difficult. A small survey we conducted as part of the PhD course, in connection with a seminar on creativity for teachers at Skive Gymnasium in Denmark (N = 70), showed that upper secondary school teachers tend to define creativity in very different ways. The 70 teachers at Skive Gymnasium were first asked which of the following four definitions best matched their understanding of creativity. They were also allowed to formulate their own definition. The figure in brackets is the number of teachers who agreed with the definition.

1. An idea is creative if you thought it up/created it on your own. It is immaterial whether others have had the same idea (N=20).
2. An idea is creative only if you have thought it up yourself *and* it diverges from the solution to the same challenge typically offered by other people (N = 21).

3. An idea is creative only if it diverges from other people's solutions and is useful/applicable. An idea cannot be creative if it cannot be put into practice (N = 19).
4. An idea is creative only if it is completely new (that is, if no one has thought of it before) and works so well that it creates or changes an area/domain (such as a subject or branch), such that new possibilities open up (N = 4).[1]

The same study also showed that many teachers are uncertain how to deliver teaching that promotes creative skills. Moreover, 45 % of teachers said that their need of more knowledge on the subject was "very significant" or "extremely significant". Only 11 % answered that their need was "slight" or that they had "no need". The remaining 44 % were "somewhat" in need of more knowledge.

According to Kampylis, Berki, and Saariluoma (2009), such a lack of knowledge and understanding can reduce the teacher's interest and motivation with respect to prioritising the matter. By means of a survey of 132 Greek teachers Kampylis found that, with respect to creativity, "*Only one in five participants (22.3 %) feels well-trained to facilitate students" creativity*" (p. 26), and concludes that, "*lack of understanding creates a lack of teachers' motivation for working towards the realization of creativity at school"* (p. 19). This may help to explain why only 43 % of the teachers at Skive Gymnasium participating in the survey felt "strongly" (26 %) or "very strongly" (17 %) *obliged* to foster the creative skills of their pupils. Also, this could point to the fact that it is hard to feel responsible for teaching something if one does not feel suitably equipped – even if the requirement has been made law.

A series of researchers (Beghetto, 2006; Fasko, 2001; Runco, 2003; Westby & Dawson, 1995) furthermore suggest the existence of an interesting dichotomy. Many teachers express a positive attitude towards creativity; research results on the other hand suggest that teachers in general do not value those personality traits that are linked with pupils' creativity (e.g. risk-taking, impulsiveness and independence). Thus, many teachers have a negative attitude towards, and low tolerance for, the behaviours and markers that are associated with creativity, even though they generally say that they appreciate creativity. One reason for this disconnect may be that it is the task of teachers to maintain *order and discipline* in the classroom (Westby & Dawson, 1995). Another reason may be that there is *uncertainty* and a considerable amount of *preparation* in connection with the activities (Aljughaiman & Mowrer-Reynolds, 2005). According to Alencar (2002:15) a result of these concerns is that many teachers adopt "restrictive practices" with respect to the realisation of pupils' creative potential, which is characterised by:

> (1) considerable emphasis on pupils providing the right answer, (2) an exaggerated focus on the reproduction of knowledge, (3) low expectations with respect to pupils' creative potential, (4) emphasis on students' compliance and passivity and (5) low priority given to pupils' use of imagination, etc.

Numerous international studies document the consequences of these five issues, citing a mismatch between creativity objectives in national curricula and actual

[1] Six teachers formulated definitions that cannot be directly matched with one of the four definitions.

outcomes (e.g. Diakidoy & Kanari, 1999; Dinca, 1999; Kampylis, 2008; Kowalski, 1997; Saarilahti, Cramond, & Sieppi, 1999).

In our study of creativity-fostering teaching in the gymnasium, we define **creativity as *the formulation of a solution that is abductive and meaningful from the individual's point of view* .** Being "meaningful" in this context is understood as something that may possibly prove to be of value, while "abduction" is understood as all types of processes where people make a qualitative leap from the incomplete data available to them, and through an element of qualified guesswork express something they have not previously created.

Such a definition allows that it is sufficient for the pupils who think them up for solutions (products) simply to be new and meaningful in relation to previous ideas they might have had. Assuming this definition, all thinking – as Dewey (1916) formulates – is *"native [and] original, with him who carries it on, even if everybody else in the world already is sure of what he is still looking for*" (p. 148). There is no requirement here that the solution be *new* compared to all others, or that it has *value*, that is, that it function as a practical solution to a specific challenge. It is enough that the individual simply incorporates creative (abductive) elements as part of his or her solution and that, at the same time, the solution appears meaningful to pursue because it represents something that may possibly have, or may later acquire, value (in the eyes of the individual creating the solution). In this understanding, creativity is a multi-faceted term covering, for example, everything from a child's spontaneous drawings to Einstein's scientific theories.

The above understanding of the concept of abduction – as reflective guesswork in all areas of life – differs from the term's original meaning for the philosopher C. Peirce (1839–1914). Peirce uses the term in a scientific-philosophical discussion of epistemological forms of working and inference, and thus does not deal explicitly with the concept of creativity. Peirce defines abduction as: "looking for a pattern in a given phenomenon and propose a hypothesis on this basis" (Peirce, 1998, vol. 2, p. 299). Or as formulated elsewhere: "… to examine a large number of facts and to allow these facts to propose a theory" (Peirce 1958: 209). The Greek philosopher Aristotle (384–322 BC) described similar ideas with the form of deduction *apagoge* – an argument that is not necessary but may be likely or possible. If the concept is relevant in this context, it is because Peirce's concept of abduction describes the thought processes which – unlike inductive and deductive forms of inference – deal with creating new ideas, hypotheses, concepts, etc., in situations where we have to try things out and make an educated guess without first having all the data (including methods) that are necessary to create reliable answers/solutions. Abduction thus seems to be present in situations where something creative is happening.[2]

[2] In an attempt to widen the concept of abduction from its narrow epistemological focus on hypothesis formation and knowledge production to also accommodate more classic creative processes such as artistic production, we can perceive abduction as "all types of processes in which we create a qualitative leap from the incomplete data we have available, and through an element of qualified guesswork express something that we have not previously created." Inspiration for such a broader

In this chapter, it is a fundamental assumption that creative products share these common characteristics (abductivity and meaningfulness) within the domain of their origin, whether we are talking about art, football, business, education science, etc. Even if creative products take different forms within different domains and may look different on the surface, they nonetheless share these fundamental characteristics. This approach follows Kupferberg et al. (2009), who maintains that we can differentiate between various creativity regimes (domains) with the same basic definition of creativity but varying ideas as to when an idea can be said to be creative, depending on the challenges and goals of the domain. Thus, various creativity regimes share the same definition – there is only one correct definition of creativity according to Kupferberg – but express it differently in the different domains.

13.4 The Empirical Approach

The aim of empirical work in this context has been to develop and examine teaching that can elucidate opportunities for strengthening pupils' creative skills, based on specific training and educational principles and input from all subjects within the traditional institutional framework of the gymnasium**.** A *primary* goal of the investigation is to find out to what degree one can identify special characteristics within teaching and educational principles across learning contexts (e.g. relating to subject, year, level, etc.) that can strengthen creative skills without compromising on academic goals. A *secondary* goal is to examine to what extent there are learning contexts where it is particularly difficult to ensure the aforementioned learning goals or where teaching may benefit from diverging from the general recommendations for creativity-fostering methods in an effort to attain the aforementioned learning goals.

The investigation will be based on so-called Educational Design Research (EDR). EDR is a relatively new set of research methodologies that are characterised by two things. *The first* is that educational researchers work with practitioners to design and implement education products which are tested, examined and improved on an ongoing basis in natural and complex teaching contexts in a way that addresses and *resolves real problems* found in practice. *The second* – with a basis in the first activity – involves education researchers developing research-based *theoretical concepts* that go beyond the specific findings of the context in which they were refined. EDR may thus be defined as a genre in which the development of iterative

understanding of abduction processes can be seen, for instance, in Johnson-Laird (2006), who describes abduction as an exercise in imagination, that is, using the capacity for imagination and fantasy – including playing with our existing knowledge. In the same style, Bateson (1984) proposes that abduction appears in metaphors, dreams, parables, allegories etc. Fredens (2009) draws a more classical parallel to the concept of creativity given in Guilford (1967) and perceives abduction as holistic/lateral thinking, that is,'out-the-box-thinking' that cuts across multiple trains of thought and therefore can break through the known framework and challenge conventional thinking.

solutions to practical, complex education problems also constitutes the framework for an empirical investigation that can lead to the formulation of theoretical concepts. In EDR, the classic distinction between research and development does not apply.

The aim of EDR is to *understand* a given phenomenon (research) and to help to *change* (develop) the phenomenon, e.g. a particular learning environment. In traditional action research (e.g. Mathiesen, 1973), gathering information and developing a theory are primarily means to improving/serving the action (i.e. resolving the practical problem). The information gathered by the researcher during the action is first applied *to the action* in an attempt to improve and refine it; it is not applied in the general development of theory. Action research may be described as follows: the action researcher is a devotee of the action, not the theory. In other words, the action is weighted more heavily and determines direction. In EDR, the opposite is the case. Here the development of didactic theory is the overall, or at the very least a subordinate, goal (Mckenney & Reeves, 2012). Furthermore, in EDR it is typically the researcher who takes the initiative in both the design process and the research process and who, together with the practitioners, identifies problems and (in collaboration) develops proposals for ways to improve practice. In action research, the role of the researcher is typically less far-reaching and in certain situations is limited to simply managing the research project (Wang & Hannafin, 2005). If one prefers the label 'action research' to EDR research, one can perhaps qualify it in relation to action research by saying that (a) the object of the exercise is always *education*, (b) the *development of theory* is at least as important as finding a solution to a practical problem and (c) the researcher has a far-reaching *role* throughout the project.

The study has been made possible through a grant from Central Denmark Region in connection with the formation of a pool of funds for youth education on the theme of "innovation and entrepreneurship" (2011). Support has also been given by Aalborg University and the gymnasium, in the form of lesson hours. The grant and application together set various guidelines for the study, which for example include *start date* (middle of 2011), *duration* (3 years),[3] *target group* (upper secondary education in Central Denmark Region), *research context* (a single, or several upper secondary education centres in Central Denmark Region), *research focus* (a topic of interest spanning subjects and institutions) and *scope* (stakeholders in Central Denmark Region). The project *practitioners*, chosen by school management, were seven teachers in 13 subjects, who each received *financial compensation* of 100 h for participating in the project. The management of the gymnasium furthermore stipulated that a condition for cooperation was that each pupil had to fill in the survey no more than twice (each time taking 20 min). This was in consideration of minimising any disturbance to pupils caused by the project.

The management of the gymnasium were instrumental in preparing the project application and subsequently appointed seven teachers, taking into account their knowledge of each individual teacher's interests, commitment, combination of sub-

[3] Since then, the project term was extended (in early 2013) to four years and the PhD staff employed on reduced hours.

Table 13.1 Overview of 27 prototypes

No	Subject	Teacher	Date
1	Social studies – terrorism	Kira	10.04.12
2	Social studies – planning/market economics	Mads P.	11.04.12
3	Social studies – globalisation/international economics	Anders	11.04.12
4	Social studies – India	Kira	24.04.12
5	Danish – Hamlet	PW	25.04.12
6	Biology – methods in genetics	Lone	25.04.12
7	Danish – Sommerfugledalen (poetry)	Ditte	27.04.12
8	Social studies – politics ('øde-ø' – the desert island)'	Anders	01.05.12
9	German – oral exercises	Bodil	02.05.12
10	English – prepositions	PW	21.05.12
11	English – prepositions(version 2)	PW	01.06.12
12	German – film analysis (control lesson)	Bodil	18.01.13
13	Social studies – the EU	Mads P.	22.01.13
14	Religion – Buddhism (text analysis)	Kira	23.01.13
15	German – film analysis and speech writing	Bodil	25.01.13
16	Biology – DNA (control lesson)	Lone	28.01.13
17	Social Studies – EU/the Council of Ministers (control lesson)	Mads P.	30.01.13
18	Social studies – politics/sociology, 95 % objective	Anders	07.02.13
19	Biology – DNA	Lone	18.02.13
20	Art – analytical strategies	Ditte	22.02.13
21	Chemistry (control lesson)	Lone	28.02.13
22	English – blogging and India	PW	12.03.13
23	English (control lesson)	PW	18.04.13
24	Chemistry – methods for identifying liquids	Lone	07.03.13
25	Danish – Impressionism (control lesson)	PW	08.10.13
26	Danish – Impressionism (text production)	PW	08.10.13
27	Biology – protein synthesis and genetic engineering	LM	03.04.14

jects and cooperation skills, etc. Table 13.1 shows the 27 classes, of which 21 are experimental lessons and six are control lessons.

As Table 13.1 shows, the 27 lessons are taken by seven secondary school teachers in 10 different subjects.

The study endeavoured to carry out its work:

- in ordinary school classes (at Viborg Gymnasium and in connection with the Higher Preparatory Course)
- within the timetable hours
- in a typical single-subject class (90 mins)
- in a subject scheduled for that particular point in time
- with the class's usual subject teacher.

13.5 Method

The study involved seven gymnasium teachers and featured 21 experimental classes. The project was introduced by way of three workshops with a focus on the challenges related to fostering pupils' creativity and possible ways of doing this. These were followed by workshops with a focus on the interim results/test results of the project and findings, with a view to refining subsequent educational product design and experimental procedures. In the *first workshop*, the researchers' initial *identification of problems and explanations for their causes* were discussed with the seven practitioners. This included a general solution based on strengthening creative skills and subject-related objectives simultaneously, within the institutional framework. The *second workshop* dealt with general *design stipulations* by way of an introduction, whereby researchers and participants pooled their thoughts. There was in particular a discussion of the definition of creativity in the context of the gymnasium, of possible task types that could set creative processes in motion and of general structures that could facilitate creative processes. In the *third workshop*, a template was agreed for *an ideal method of cooperation* between researcher and teacher with respect to developing specific measures.

We identified nine chosen design stipulations, whose aim was to place pupils under *pressure* to create. This would necessitate creative *processes*, whereby creative *skills* would be developed. The design stipulations were: (1) problem solving, (2) realistic tasks, (3) encrypted data, (4) distinct work procedures and deferred assessment, (5) individual idea generation and 'brainwriting', (6) clear and significant productivity demands, (7) structured analysis, (8) cooperation and (9) feedback.

The nine design stipulations were assembled in a version of the creative process model (Mumford, Medeiros, & Partlow, 2012) specially adapted for teaching and detailed in three main phases in which pupils: (a) are given a *task* to solve (abductive opening), (b) propose solutions through *idea generation* (abductive searching) and (c) take part in *technical debriefing* with an analysis, assessment and clarification of technical errors and deficiencies (abductive transfer). Each main phase is linked with three of the nine design stipulations. Other researchers will be unlikely to have assembled exactly this model or set of design stipulations. There must necessarily be an element of choice and interpretation when selecting fundamental design requirements based on the literature.

Table 13.2 combines the overall abduction-didactic model – including the three stages – with the design assumptions identified in the existing literature.

When teachers are to construct their own trial activities in accordance with the above model, the three stages are considered to be ones that must be followed (MUST assumptions), while the content of the 9 design assumptions is considered to be something that can be followed (CAN assumptions). Teachers in the project have composed the study's trial lessons and control lessons with very different tasks, processes, deadlines, etc. A typical lesson design is illustrated in Table 13.8. The academic questions in the task are themselves the basic element that determines to what

Table 13.2 The coupling between the didactic model and design assumptions

Model phase (BE)	Design assumptions (KAN)
Phase 1: abductive opening	Compared to Phase 1, this basically involves principles that can guide teachers in creating tasks which:
=Pupils receive an *assignment* they must solve which requires abduction	(1) focus on problem solving
	(2) are realistic
	(3) are formulated in areas where pupils have a degree of knowledge (encoded data)
Phase 2: Adductive search	In comparison, phase 2 basically concerns principles that can guide teachers in the use of:
=Pupils create answers/proposals using *idea generation (abduction).*	(4) separate work processes
	(5) individual idea generation and brainwriting
	(6) clear and high-level production requirements
Phase 3: Abductive transfer	In comparison with Phase 3, this basically concerns principles that can guide teachers in:
=The pupils participate in *technical debriefing*, which makes clear the technical faults/omissions (e.g. via analysis and assessment).	(7) structuring the pupil's analysis
	(8) establishing cooperation in the analysis phase
	(9) providing feedback for pupils

extent abductive processes are involved. The questions should also guide the choice of specific processes, tools, etc. The project has identified 10 basic types of abductive questions (in the thesis these are called "abductive openers") where pupils can work on creating more or less good solutions. For example, assignments that require pupils to develop ideas for explanations, interpretations, analogies, definitions, simplifications, stories, visualizations/formulations, problem solutions, study design and bodily movements. All these types of questions can be designed so that pupils do not know the solutions in advance and cannot find them via formulas, recipes or specific procedures – and thus must make their own abductions (proposals). In fact the only requirement is that pupils work on creating solutions with quality, and that the quality of the solutions can subsequently be made clear to a greater or lesser extent. Appendix elaborates the 10 identified forms of abduction and provides examples.

13.5.1 Observation of Classes

Each of the lessons was observed by the PhD student. Observation of lessons was *not* intended to result in specific statements about the degree of learning, skills development etc. that took place during the lesson for each pupil, or to derive from that anything about the quality of the design stipulations.

13.5.2 The Pupil Questionnaire

All pupils taking part in an experimental class filled out a *questionnaire* at the end of the class. One role of the questionnaire was to capture the individual's experience of the experimental lesson.

13.5.3 Focus Group Interview with Teachers

Towards the end of the project, as results began to emerge, it was furthermore decided to conduct a semi-structured, group interview with a focus group of seven teachers, which would last 3 h and deal with issues of quality. The purpose of the focus group interview was, among other things, to recreate group processes, to activate forgotten details and to formulate a basis for comparison. This would in theory enable participants to express themselves explicitly on aspects of their experience that they may not have consciously noted, or to add details to the statements of others where they sympathised with these (Crabtree, Yanoshik, Miller, & O'Connor, 1993, Krueger, 1998, Kvale & Brinkman, 2011, Merton, Fiske, & Kendall, 1990).

13.6 Results

Findings from the project experiment, with the three phases and nine design stipulations, have led to several main conclusions.

First the study shows that the experimental lessons were, in general, significantly better at fostering pupils' creative skills than the control lessons and that there seems to be no difference in the degree of academic learning in the situations chosen by teachers (see Table 13.3). This suggests that there is an opportunity for introducing creativity to a variety of academic areas and task types in gymnasiums and therefore developing broad-spectrum creative skills.

This is especially positive, because creative skills consist of various elements in various situations and are determined by the type of task (DeSeCo, 2002) – and because there is a greater transfer from the learning context to the application context, the more varied the learning context are (Yamnill & McLean, 2001). Added to this, teaching creative skills is not just a matter of developing certain cognitive structures, practical skills, etc., but also about providing experience (work habits) of various applications. It is therefore crucial that creative skills are not taught through standard exercises that are detached from real application scenarios (such as 'find potential applications for a sock') but that they can be imparted through a wide range of contexts specific to the discipline.

Second, the study highlighted several interesting *relations* between abductivity, motivation and academic content. For example, it was found that pupils' motivation fell more sharply in control lessons ($r = -0.34$) than in experimental lessons (-0.07) in a subject that was felt to be difficult (see Table 13.4). In other words, pupils seem to

Table 13.3 Differences in creativity sub-objectives and overall objectives between control and experimental lessons

	N	Control lessons	N	Experimental lessons	Difference (Δ)	P-value
Academic level	128	0.13 (0.01;0.25)	362	0.05 (–0.03;0.14)	–0.08 (–0.25;0.08)	0.34
Motivation	129	0.13 (–0.02;0.27)	366	0.78 (0.69;0.87)	0.66 (0.48;0.83)	<0.001
Abductivity	129	–0.34 (–0.55;–0.14)	436	0.74 (0.66;0.83)	1.07 (0.90;1.28)	<0.001
Creativity	128	–0.10 (–0.43;0.22)	357	1.55 (1.36;1.74)	1.65 (1.28;2.02)	<0.001

Pupils were asked to give a score reflecting what they felt about academic content, motivation and abductivity in the specific lessons, based on a 5-point scale ("very high" (+2), "high" (+1), "some" (0), "low" (−1), "none" (−2))
The figures are calculated on an average of 95 % CI and were adjusted for background variables (such as gender, age, year, subject and level)
The degree of creativity was found by adding the pupil's answers to the three aspects of academic content, motivation and abductivity
Example: In the experimental lessons, pupils gave a score of +0.74 for the experience of using their imagination (abductivity): this corresponds most closely with "high". The same result for the control lessons was −0.34. This represents 15 pupils in an experimental lesson (involving 20 pupils) answering "high" and five pupils answering "some"; and seven pupils in a control lesson (involving 20 pupils) answering "low" and 13 "some"

Table 13.4 Correlation between creativity sub-objectives in experimental and control lessons

	Abductivity		Resistance		Academic level	
	Control	Experim.	Control	Experim.	Control	Experim.
Motivation	r=0.16**	r=0.18*	r=–0.34**	r=–0.07	r=0.43**	r=0.25*
Academic level	r=0.07	r=0.14	r=–0.16*	r=0.07		
Resistance	r=–0.04	r=–0.04				

The correlation coefficient (r) shows the relation between the creativity sub-objectives. The number (r) is always between −1 and 1. If the number is positive, one indicator rises when the other rises. If the number is negative, one indicator falls when the other falls. If, for example, the number is 0.50, this means that one variable explains 25 % (0.50 * 0.50) of the variation in the other
The numbers in bold are correlations in experimental lessons. Other numbers are correlations in control lessons
* P<0.05 ** P<0.001

have better staying power in an experimental lesson than in a control lesson. Furthermore, resistance seems to reduce academic learning in control lessons (r=–0.16*), but not in the experimental lessons (r=0.07). Finally, it seems that pupils' motivation rises with greater demands on them to provide new (imaginative) answers.

Third, the study shows the significance of various background variables. For example, it appears that the superordinate *discipline* (humanities, social science, natural science) seems to be influential. Pupils record greater motivation and academic content in the humanities compared with the social and natural sciences (see Table 13.5).

Table 13.5 Significance of academic subject for creativity sub-objectives and overall objectives

	Motivation		Abductivity		Academic level		Overall	
	Experim.	Control	Experim.	Control	Experim.	Control	Experim.	Control
Humanities	Reference	Reference	Reference	Reference[a]	Reference[a]	Reference	Reference	Reference
Natural sciences	−0.29*	−0.11	−0.09	−1.49[b]	−0.19[ab]	0.01	−0.45	−1.56
Social science	−0.05	0.02	−0.15	−1.69[b]	−0.22*[b]	0.12	−0.48	1.53

In experimental lessons, "N" must not exceed = 436. In control lessons, "N" must not exceed = 129
Letters in a series (a, b, c) indicate a significant difference between various reference points
Asterisks (* or **) indicate significance in a single value, where no reference point was sought (* $P<0.05$ and ** $P<0.001$)

Table 13.6 Comparison of creativity indicators in various types of lesson

	Control (12, 16, 17, 21, 23, 25)		Imaginary (1, 3, 4, 24)		Real (2, 5, 6, 8, 9, 13, 15, 22, 26)		Classroom (7, 10, 11, 14, 19, 20)	
	N	Average (95%CI)	N	Average (95%CI)	N	Average (95%CI)	N	Average (95%CI)
Academic level	128	Reference[a]	151	–0.08 (–0.27;0.11)	60	–0.34 (–0.59;–0.09)[b]	138	0.01 (–0.18;0.21)
Motivation	129	Reference[a]	151	0.88 (0.68;1.08)[b]	60	0.40 (0.14;0.66)[c]	142	0.49 (0.29;0.69)[c]
Abductivity	129	Reference[a]	183	1.27 (1.06;1.49)[b]	95	0.88 (0.62;1.13)[c]	145	0.97 (0.74;1.20)[c]
Creativity	103	Reference[a]	86	2.11 (1.66;2.72)[b]	49	0.89 (0.44;1.70)[c]	53	1.32 (0.95;2.17)[bc]

Letters in a series (a, b, c) indicate a significant difference

This suggests that teachers of the social and natural sciences should be particularly attentive to the need to give pupils sufficient information and ensure thorough feedback. The difference in motivation and academic content is however less marked in experimental lessons than in control lessons. The experimental lessons were, it would seem, good at limiting the difference in the need for abductivity between subjects and thus could neutralise what one might call the 'monopoly' of humanities on creativity.

13.6.1 Main Findings from Phase 1 (Abductive Opening)

Under *Phase 1* in the model for abductive learning, the lesson should provide a *task* that pupils can try to solve using abductive reasoning. In other words, pupils should be given a task for which they do not know the solution, or cannot derive an answer using familiar methods. Instead they must offer ideas based on their existing knowledge. There are three design stipulations with a special connection to Phase 1. These are stipulations that can guide teachers in creating tasks, taking into account: (1) problem solving, (2) realism and (3) encrypted data. Findings from the study's experiments in Phase 1 suggest several main conclusions with respect to the design of problem-based and realistic tasks.

First it seems that learning outcomes are slightly *reduced* if the pupil is asked to give interpretations, explanations, recommendations, etc. on a more general *understanding-related* problem ("in the outside world"). Such a problem might for instance require proposals for solving general problems related to terrorism or the interpretation of fundamental elements of Buddhism (see Table 13.6). Perhaps the reason for reduced learning outcomes is that technical learning elements may be abstract and difficult to relate to and pupils may feel that they lack the knowledge for solving real-life, complex problems.

Second, it seems that learning outcomes are relatively *reinforced*, together with motivation and abductivity, when tasks relate to *specific* examples that pupils can relate to and which they are asked to *imagine* themselves being in, as well as actually solving a particular challenge that requires various forms of personal involvement (e.g. being shipwrecked on a desert island, a member of a flying squad, or a writer in Shakespeare's workshop, etc.) (see Table 13.6). Pupils appear to see these types of task as clearer, more relevant and more interesting. This would suggest that problem-based and realistic tasks could benefit from the inclusion of certain imaginary elements (e.g. working with hypothetical, rather than real, climate-change problems).

Third, it is important that creative skills are taught in areas where pupils have a *degree of knowledge*, since new ideas are created on the basis of our existing knowledge. Pupils' knowledge should be neither *over-codified* – in that they have so much knowledge that solutions more or less suggest themselves – nor *uncodified*, in that they possess insufficient knowledge on which to build their solutions. Pupils' knowledge should preferably be *encrypted*, so that they have enough knowledge to understand the problem inherent in the task, have some idea of which solutions would not work and can infer the directions in which sensible solutions might be found, without having so much insight that the answer is self-evident. This is confirmed by the detailed answers pupils gave in experimental lessons (13, 24, 19, 15), which are least positive in terms of effect. These evaluations are typically given when pupils either have *too much* knowledge and thus feel that the lesson is pure revision and does not result in learning new facts or in creative challenges (which seems to be the case for lessons 13 and 15); or *too little* knowledge and thus feel that the creative challenges of the lesson are too difficult and represent a barrier to academic learning (which seems to apply to lessons 19 and 24).

13.6.2 Main Findings in Phase 2 (Abductive Searching)

According to *Phase 2* of the model for abductive learning, teaching should involve search processes whereby pupils apply abductive procedures in an attempt to create their proposed solutions to the relevant task. There are three research-supported design stipulations with a special connection to Phase 2 of the model. These are stipulations focusing on: (4) distinct work procedures and deferred assessment, (5) individual idea generation and 'brainwriting' and (6) clear and significant productivity demands. Findings from the study's experiments in Phase 2 suggest several main conclusions with respect to the design of distinct work procedures, individual idea generation and brainwriting.

First, in only 14 of the 21 experimental lessons was it possible to ensure a clear distinction between idea generation and work procedures with evaluation (see Table 13.7). In the remaining seven experimental lessons, pupils were told – either alone or in groups – to alternate between idea generation, analysis, evaluation, etc. in creating *a single* finished answer.

Table 13.7 Work procedures in the 21 experimental lessons

	1	2	3	4	5	6	7	8	9	10	11	13	14	15	18	19	20	22	24	26	27
Plenum/teacher presentation					x	x		x		x	x					x	x	x	x		
Preparatory pupil work					x	x		x	x	x	x					x					x
Idea generation (individual)	x	x	x	x		x	x	x				x	x		x	x	x	x	x		
Idea generation (pairs/groups)																					
Categorisation		x										x			x						
Discard identical ideas							x						x								
Assess/choose ideas (alone)				x																	
Assess/choose ideas (in pairs)	x																	x			
Assess/choose ideas (in groups)	x	x	x	x			x					x			x	x			x		
Build on answers			x	x		x		x				x	x						x		
Produce a single answer			x		x		x			x	x		x	x			x	x	x	x	x
Critique of answer														x							
Presentation in groups (with critique)												x						x			
Adjust according to critique/inspiration														x		x					
Vote casting		x										x									
Prepare presentation								x													
Pupils read each others' answers																				x	
Presentation in plenum (teacher contribution)			x		x		x	x					x	x		x	x				
Plenum (assessment of pupils' answers)	x	x				x	x	x		x	x				x			x			

Lack of distinct procedures in these lessons is not caused by a lack of will on the part of the teachers. It is caused by the fact that the principle has proved more difficult to implement in certain situations than the literature would suggest. Such situations include, for example, *the reconstruction of everyday settings* in which the pupil is asked to quickly provide the best possible answer; and *art workshops* in which the pupil is asked to paint, draw, write a poem, sculpt, etc. and where the solution requires a series of very small ("nano") abductive actions, that have to be corrected and adapted to each other throughout the process. If one insists on using distinct work procedures in such situations, the risk is that the task will become artificial and drawn-out. Furthermore, it was not possible to document the advantages of differentiation when comparing lessons with and without distinct methods.

Table 13.8 Typical design of a lesson

Model	Activity	Time (70 mins)
Phase 1	Stimuli	5 mins
	Task – presentation	5 mins
Phase 2	Initial idea generation	5 mins
	Analysis	20 mins
	Categorisation	(5–10 mins)
	Initial choice of ideas	(5–10 mins)
	Further development/critique	(5–10 mins)
Phase 3	Presentation	15 mins
	Summary	15 mins

Second, and for a similar reason, it was possible to establish individual brainwriting in only 14 of the 21 experimental lessons. In the remaining seven experimental lessons, pupils were instead asked to mix idea generation, analysis, evaluation, etc. in the creation of *a single* finished answer (cf. the challenge of setting up differentiated work procedures) – either *alone* (lessons 9, 10, 11) or in *groups* (lessons 5, 15, 26). In such situations, one must choose between running the whole process based on the individual or on groups and, while it may seem relevant to conduct idea generation individually, there are advantages in running the analysis part in groups (cf. design stipulation 8). This means that, despite existing research, it is unclear to what extent idea generation should be conducted on an individual basis.

13.6.3 Main Findings from Phase 3 (Abductive Transfer)

Under *Phase 3* of the model for abductive learning, teaching must include a *technical debriefing*, in which the strengths, errors and weaknesses of the pupil's work are discussed. Pupils must take part in several processes to hone their original proposed solution to the task in question. There are three research-supported design stipulations with a special connection to Phase 3 of the model for abductive learning. These stipulations are intended to help teachers (7) structure the pupil's analysis, (8) establish cooperation in the analysis phases and (9) give feedback to the pupil. Findings from the study's experiments in Phase 2 suggest several main conclusions with respect to the design of analysis, cooperation and feedback.

First, the number of work procedures with analytical content can vary from one to five. In a typical lesson plan, it is possible to devote only 5–10 min to each of the work procedures (see Table 13.8).

This makes it difficult to make use of the highly structured analysis techniques recommended in the literature (such as matrices, SWOT analysis, etc.), according to which advantages and disadvantages of all the chosen ideas are systematically listed. Instead, various critical, intuitive analysis phases were used.

Second, it seems that a large number of distinct analysis phases does not create better educational outcomes than a small number of distinct phases (which is

Table 13.9 Number of work procedures with analytical content seen in relation to outcomes

Task	Experimental lessons	Motivation	Abductivity	Technical learning	Creativity	N
Control lesson	12, 16, 17, 21, 23, 25	Reference	Reference[a]	Reference	Reference	129
Low frequency	6, 9, 10, 11, 20, 26	0.45	1.74*[b]	<0.04	1.71	136
Medium frequency	1, 4, 18, 19, 24	0.07	1.54**[b]	<0.47	1.16	80
High frequency	2, 3, 7, 8, 13, 14, 15, 22	0.12	1.83**[b]	<0.34	1.31	141

Letters in a series (a, b, c) indicate a significant difference between various reference points
* $P<0.05$ and ** $P<0.001$

assumed in design stipulation 7). This can be seen in Table 13.9, which categorises the experimental lessons based on number of analysis phases (high, medium and low frequency).

Pupils' own detailed answers suggest several possible explanations. For example, a large number of disparate work procedures can create confusion and unrest in a lesson lasting 60–90 min and mean that pupils do not have the chance to concentrate on the longer work procedures. In the same way, where lessons feature a lot of work procedures, pupils typically work on several different questions and are thus subject to greater pressure, which may hinder the attainment of positive results. Moreover, pupils do not always make a clear distinction between the various work procedures, repeating some types of work and finding that some procedures are unproductive.

Third, it would appear sensible to set up cooperation (e.g. working in groups) in the analysis phase. Cooperation in the analysis phase is one of the traits of the 21 experimental lessons that pupils most often volunteer to comment on (even though they are normally fairly sceptical about group work in general). The need for work in groups perhaps arises because pupils do not know the answer to the task in advance, cannot find it in the book, are uncertain of their own answers and can therefore see the benefit of working in groups during experimental lessons. In comparison, group work is traditionally used for classes where pupils are asked to give answers on reading they have done at home and thus should not in fact need each others' help, if they have done their reading. The above is reinforced by teachers' statements. For instance, Kira says:

> *… I think their most positive reaction – almost irrespective of class – was when allowed to view each other's work. This is where the best outcome can be found (…) inspiration in technical matters has a very significant effect for them.*

Anders adds:

> *… they realise that what they are doing is meaningful and will be used in other situations, because other groups will continue to work on it or comment on it. This also creates an obligation so that they feel 'we'd better do something good.*

Cooperation is also relatively easy to establish in the Higher Preparatory Course. Classes typically have a suitable number of pupils (20+), tables and chairs are

Table 13.10 Is it important for the teacher to explain which answers are right or wrong at the end of the lesson? (N = 194)

Very important	Important	Of some significance	Slightly important	Not at all important
62 pupils	65 pupils	47 pupils	15 pupils	5 pupils
31 %	32 %	25 %	8 %	3 %

movable, groups can go into break-out rooms and pupils are accustomed to working in groups. Furthermore, the analysis phase lends itself to group work *after* idea generation by individuals and *before* a plenary session. For example, groups can distil a large number of individual ideas down to a few group ideas, which are easier for the teacher to handle in the plenary session.

Fourth, it would seem advisable to give concluding feedback – which should include an opportunity for the pupil to evaluate the quality of their own work – where pupils have attempted to create new proposals. Only 11 % of pupils involved in the project gave the answer "slightly" or "not at all" to the question *"Is it important for the teacher to explain which answers are right or wrong at the end of the lesson?"* (see Table 13.10).

Pupils typically explain why they welcome feedback by saying that it means they *"… don't go home with the wrong understanding of things", "… can correct mistakes and be guided towards the right methods", "… know what the right answers are and are thus prepared for the exam"*. However, there is some variation in pupils' appreciation of feedback depending on the individual lesson. Part of this may be due to the different types of knowledge in various subjects and disciplines. Feedback seems most needed in scientific subjects and least needed in the arts and humanities (see Table 13.11).

Besides this, there can of course be differences between individual subjects. This depends, among other things, on the type of knowledge being worked with in the specific lesson. Research into the way teachers should deliver their feedback is scant (Meyer, 2010) and the findings of our study and the experimental lessons are not able to contribute very much. Pupils say that feedback need not always be given at the end of the lesson, that it should be balanced with other learning elements, and that the teacher should try to focus on the positive contribution made by pupils.

13.7 Main Conclusions

The empirical study referenced in this chapter had two overriding and interconnected goals.

- First – it aimed to design and implement practical education products etc. in natural and complex learning contexts that would help pupils tackle and solve real practical problems.
- Second (and based on the first goal) – it endeavoured to develop evidence-based theoretical concepts that would extend beyond the specific findings of the context in which they were refined.

Table 13.11 Feedback in relation to discipline

Discipline	Feedback
Humanities	Reference[a]
Natural sciences	0.77**[b]
Social science	+0.40*[c]

Letters in a series (a, b, c) indicate a significant difference between various reference points
* P < 0.05 and ** P < 0.001

The first aim is secondary from the point of view of research and is primarily a means to try out certain design stipulations in the effort to gain a new understanding of issues concerning creativity – this effort being the ultimate objective of the study.

13.7.1 Practice (Practical Education Products)

With respect to practice, the study points towards what we may call an 'abductive didactics' model. This model holds that pupils should be given subject-related tasks that challenge them to engage in meaningful abductive reasoning, as relevant to the subject. At the same time, there should be a (concluding) reference to the existing answers provided in the field, perhaps by means of a debriefing phase with teacher input. It does not need to be more complicated than this. Therefore, the development work illustrates that sometimes we have to go the long way round to come to a simple conclusion.

Abductive reasoning exercises are (of course) already in use in the gymnasium. It is in fact impossible to conduct a lesson without *some* pupils on *some* occasions using abductive reasoning to seek an answer, without being certain of their knowledge or the conventional method. For example, teachers often set tasks that cover material that has not been read or that refer to reading material where the pupil may not remember the facts. When designing suitable educational activities for the purpose, the educational scientist must essentially investigate the best way to incorporate in their design abductive work procedures that take account of various teaching goals.

The study has:

- shown that it is possible to incorporate abductive procedures without compromising the learning goals of the discipline. This does not have to be complicated.
- underlined the importance of considering the way procedures are designed, in order to gain the best possible benefit. Often, a lesson is successful when abductive work procedures are formulated with *imaginary* elements (as opposed to "real problems") in areas in which pupils have *uncodified knowledge* and when *cooperation* and *concluding feedback* are incorporated in the analysis phase.

- shown that one cannot take the nine design stipulations as a detailed nine-point manual that dictates how teachers should act when setting out to promote creative skills and subject-related learning goals. The classroom is not a straightforward cause-and-effect system. Some of the best-recognised principles for fostering creativity – such as distinct work procedures, deferment of assessment, individual's idea generation and structured analysis techniques are often impossible to apply or unsuitable in specific educational contexts in the gymnasium. This may be due to the nature of the subject, the length of the lesson or the difficulty of combining these principles with other design stipulations.

The very general conclusion to the project is thus that *teachers* must feel their way forward and notice what works in practice in various contexts when considering the above recommendations. They may consider the results as professional tools to enable reflection, which may be consulted when planning specific lessons with the stated aims.

13.7.2 Theory (Theoretical Concepts)

It is difficult to make a clear distinction between the outcome of the study's attempt to improve *practice* (that is, the didactic model with design stipulations) and the general insights concerning design stipulations, which the study subsequently attempts to consolidate in domain-specific *theories* (design *principles*). The practical aim of the study was thus to identify, examine and adapt more general design stipulations that teachers could use subsequently as an overall framework or model for designing specific lesson types. It is therefore hard to differentiate between such a practical aim and the primary theoretical aim of the study – namely, to develop evidence-based theoretical concepts (design principles).

The above findings concerning the nine design principles can also be taken as theoretical contributions in the above sense. Besides these findings, one can also draw a series of more general theoretical and methodical conclusions as milestones in relation to research in this field. These relate, among other things, to:

- how to *define* and understand creativity in an educational context
- (= as a proposal formulated by the pupil that has been arrived at through abductive reasoning and is a meaningful response to the task from the point of view of the pupil);
- how one can *study* creative skills in an education context
- (=as the pupil's experience of the need/pressure to use abductive reasoning rather than, for example, the number of ideas generated);
- how to view the *conflict* between creativity and technicality (and internal/external motivation)
- (=using the perspective of differentiation rather than the perspective of harmony or disharmony);

- which *procedures* should be focussed on when trying to promote the two learning goals
- (=the three phases in an abductive didactics model rather than the eight phases in Mumford's CP model).

In conclusion, one can ascertain that researchers should examine the theoretical relation between creativity and technical learning goals while bearing in mind the complexity and the traits of a particular situation that seem to characterise the relation. Hence, the subject that is being taught, what pupils know about the subject in advance, what type of technical knowledge pupils must work with (e.g. introduction, summary, etc.), how often pupils can be motivated to take an active part and how long it takes the teacher to prepare this type of lesson, etc. are not insignificant considerations.

13.8 Limitations of the Analysis and Future Empirical Work

In conclusion, it is now the intention to examine more closely the survey's *research perspectives*, taking a special look at what future, additional research studies the above results and limitations could point to. In this connection, a distinction is made between the studies which have a different *subject area* (e.g. one subject or one class), and studies that use other *methods* (e.g. quantitative tests and qualitative pupil interviews).

The subject area of the study is basically all subjects and academic topics, etc. It goes without saying that it is not possible to cover this whole subject area with 21 trial lessons. This means that the study (at best) can only say something specific about the academic topics, design assumptions, etc., which the teachers select for trial lessons and from there they must try to say something indicative about which lesson types are most useful for the dissertation's model and design assumptions and thus may be expected to be able to be extended to. In an effort to say something in more detail about the opportunities and challenges within a single subject– for example, examining how often the process can be used successfully within one specific subject – it could be interesting to select one subject for a further study.

In order to say something in more detail about how great an effect learning activities create in the long-term, and how much of the daily lessons they should take up, it could accordingly be interesting to investigate one class which for a longer period of time received abductive instruction from all of its teachers in all lessons.

The study's *investigation methods* are primarily oriented around a questionnaire interview with pupils in connection with the trial and control lessons. In an effort to say something in more detail about which design principles work, when and why, in relation to the different types of pupils, it would be possible, for example, to supplement the above studies with qualitative pupil interviews. For example, by following up the different trial lessons by appointing two interview groups – a group of pupils who are most positive about the teaching method, and a group of pupils who are

least positive about the teaching method. This could help to indicate what might possibly be changed if different groups of pupils are to learn more through the teaching method and why it might work better with regard to some lessons and pupil types than others. In an effort to establish more reliable, quantifiable data with respect to the trial teaching, one could also establish permanent trial classes and permanent control classes (with the same teachers, subjects, etc.) and continuous measurement of progress in the two groups (e.g., with regard to academic learning, the ability to solve relevant problems, etc.). Such an approach with quantitative testing could to a greater or lesser extent be structured as a randomized, controlled study. Among other things, this will make it easier to measure the desired effects – such as the development of creative skills – over a longer period than is possible with individual lessons of 60–90 min. The challenges inherent in such an approach are comprehensively covered in the existing literature.

13.9 Appendix: Ten Abductive Openers

1. **Explanation**
   Explaining the connection behind observed phenomena. For example, by selecting a cause, rule or regularity that can explain or predict one or more individual situations.

   Examples:

   - Why do some things sink while others float?
   - Why are terrorists willing to die for their faith?
   - What principle is … the common denominator in the following 5 sentences?
   - Why do certain animals have the colours that they have?
   - Why do we use proverbs and sayings and what do they do with the language?
   - What would happen … in Afghanistan if … the Allies withdrew?

2. **Interpretation**
   Interpreting how a given message should/could be understood. For example, by finding meanings in situations where the understanding/meaning is not necessarily visible or follows from the pure linguistic meaning of the words.

   Examples:

   - How can the following text excerpts be interpreted....?
   - What does Hans Christian Andersen want to say with…?
   - What is meant by the following English expressions: "*To have ants in one's pants*".
   - What did Plato mean with his parable of the cave?

3. **Analogy**
   Comparing/describing/explaining "something" with "something else". For example, transferring the characteristics of one context to apply in another context (e.g. the perception of society as an organism).

Examples:

- Find a different context where knowledge about … "bipolar power" can be used.
- Describe democracy (to the ignorant) without using the following words: *majority, all, part.*
- Create an analogy that can explain the concept of "gravity".
- Create mental recall rules for the chemical symbol for lead (PB) – for example, Plum Bum.

4. **Definition**
   Defining a concept – including the assembly of a number of individual cases into a new concept.

   Examples:

   - Give a definition of the concept…. (energy, democracy, faith, adventure, etc.).
   - What do you think characterizes the following concepts…. (energy, democracy, faith, adventure, etc.).
   - Categorize the following individual cases into certain groups/concepts…: e.g. political attitudes, living beings, and chemical elements.

5. **Investigation**
   Devising a (new) way of investigating or experimenting with certain phenomena.

   Examples:

   - Devise a method that can investigate/clarify… high school culture.
   - Devise a method that can investigate/clarify… whether people are believers.
   - Devise a method to investigate/calculate… the law of gravity.
   - Devise a method to investigate the importance of getting… liquids, sleep, etc.
   - Devise a method that can investigate… the meaning of life ☺.

6. **Simplification**
   Reducing complex phenomena and contexts. For example, by devising ideal types, models, heuristics ("rules of thumb"), examples or simplifications.

   Examples:

   - Explain … the law of gravity to a child in kindergarten.
   - Create a *model* of … what determines the positions of the political parties.
   - Give rules of thumb for what typically explains … a person's religious nature.
   - Give *examples* of … what a street child must experience in a single day.
   - Describe what characterizes a *typical*… high school pupil (or Muslim).

7. **Problem**
   Developing products, processes, laws, etc. that can solve specific challenges/problems.

Examples:

- How can we solve the problem of … poverty, climate?
- How should you create … an economic system on a desert island (a new EU, a new religion)?
- How can you create … wind turbines that can operate in a desert landscape
- How should Obama tackle the relationship with Russia?
- Imagine … that you are Hitler and have to convince the people that they have to go to war.

8. **Story**
   Creating free stories. For example, on the basis of certain keywords or perspectives (stimuli).

   Examples:

   - Create a meaningful narrative from the following 5 keywords…
   - Create a story in a certain style… for example, a fairy tale…
   - Imagine that you are…
     - *an ethnologist* who is observing how an unknown tribe worships their god (what happens?).
     - *a researcher* who discovers gravity on an alien planet (what characterizes it?).
     - *God*, who has to design atoms on a new planet (what characterizes them?).

9. **Formulation**
   To use one's motor perceptual (silent) system to form certain thoughts, desires, goals, etc. or to reshape concrete/abstract knowledge into alternative forms of expression.

   Examples:

   - Draw, paint, build, mime, dance, act out, etc. a concept (democracy), a theory, etc.
   - Rewrite a message in a certain style, such as a political speech, newspaper, lyrical poem, etc.
   - Write a free sentence (10–20 words), which uses the tone of a certain style.

10. **Body**
    Using one's body in ways one has not previously done. For example, on the basis of certain keywords or perspectives (stimuli).

    Examples:

    - invent a new dance, way of walking, double backhand, high jump technique, drum style, way of talking, sleeping, eating, etc.

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