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Science for Practice – Scientific Practice
The Constructive Foundation of a Scientific University Education

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1 Posing the Question

On the 19th of June 1999 the Bologna Declaration was signed by 29 European ministers of education. In it the goals were spelt out which were seen as being of the highest priority for European institutions of tertiary education. Among them was the creation of a two-stage system of final qualifications through the introduction of studies leading to the acquisition of bachelor- and master-degrees. In Germany institutes of tertiary education are authorized to introduce courses of studies leading to a master- or a bachelor-degree within the framework of the legislation of the Hochschulrahmengesetz (Tertiary Institutions Framing Legislation and Regulations Act). Once the Hochschulrahmengesetz had been adapted to allow this to happen in Schleswig-Holstein in the year 2000, tertiary institutions in this state of the Federal Republic of Germany will also be able award bachelor-degrees as final and master-degrees as post-graduate qualifications. Like other institutions of the Christian-Albrechts University in Kiel, the Institute of Education is obliged to introduce the new courses of study.

The present reform of university education is a controversial subject of heated discussion. The debate over the introduction of bachelor- and master-study courses varies from a position of consent to one of refusal. On one side of the debate decisive advantages are awaited from the reform, ranging from the reduction of the length of time taken to complete a given course of studies, greater flexibility in the contents of a given course of studies, and an improvement in the comparability of performance between different courses of studies at both a national and an international level. On the other side of the debate first experiences of the new system are pointed to warningly as indications appear that the length of time that it was planned should normally be allowed under the new regulations to complete a bachelor- or master-degree threatens to be exceeded by the initial batch of students. The introduction of modularisation in teaching, the introduction of performance assessment on a points-basis according to the ECTS System, and an accreditation procedure as well will lead to a significant increase in the workload of tertiary institutions and will lead to a restriction of the mobility and compatibility of students in their movements from one tertiary institution to another. The debate is weighed down by a lack of evidence derived from research efforts accompanying the reform process.

In the following the question will be investigated which can be posed in connection with this intended educational reform. Although neither the Bologna Declaration nor the legislation in vigour give explicit instructions in this respect, nonetheless the integration of theory and the process pertaining to its application seem to belong to the highest priority goals of the reform of modern education. ‘Science for Practice’ can be regarded as the distinguishing characteristic and slogan of the new academic degrees. In this contribution the question to be cleared up is how a university education is to be structured in order that it can simultaneously be both scientific and practice oriented.

2 The Crisis of Modern Science

The starting point for the choice of a suitable scientific paradigm is the crisis of modern science. A question which is still unsolved at present is how it is possible to provide a rational foundation for theories. The difficulties with regard to the possible provision of a grounding for science are described by ALBERT with the expression ‘Munchausian Trilemma’ (ALBERT 1975, 11-15, 183-210). According to ALBERT the deductive grounding of science is confronted by three equally problematic alternatives. The first is an endless regress, in the framework of which the chain of propositions which are

drawn into the grounding argument never terminates. The second unacceptable alternative takes the form of a circular grounding argument, in which the propositions used appear as the basis of the grounds for having good reason to believe in their own validity. Just as problematic is the third alternative which is the dogmatic insistence on perceiving a grounds of justification in the declaration that it is not in need of anyuch basis. The uncertainty concerning its foundations results in the methods and goals of science being placed in question.

This failure leads scientists to retreat into the contemplation of relationships which are internal to scientific theory. Science so conceived is reduced to the interpretation of mathematical and logical descriptions. For these restrictions of the area of validity of scientific pronouncements ALBERT introduced the term 'Model Platonism' (ALBERT 1967).

The preconditions and consequences of Model Platonism can be identified in educational measurement. In the scientific program of the Logical Empiricism a theory is developed (BUNGE 1967, 483 seqq.) in which one introduces so called basic terminology. These are the symbols of a formal language, which possesses absolutely no relation to reality. BUNGE (1967, 483 seqq.) refers to uninterpreted symbols such as '⊗', '#', 'x', 't' or 'e' as semantically abstract. These symbols represent the meaningless basic components of a language. With their help axioms are then developed, which are equally only formal relationships. Together with rules of syntax they present the characteristics of a theory which would be described as axiomised and abstract. It has not one iota of empirical relevance.

Examples of axiomatic theories are the classic and the probabilistic test theory. The multitude of tests and surveys, which are used in the present age, are based on the classical theory. However written and oral examinations, lacking a suitable alternative, often are given using them as a model. The more modern probabilistic theory is employed in international comparative studies TIMMS (compare BAUMERT et al.1997) and PISA (compare BAUMERT et al. 2001). Classical and probabilistic test theories are visibly similar to and approach the model platonic point of view. This point of view will be illustrated using the classical approach in the following.

The classical test theory in its formulation by GULLIKSEN (1950) is an abstract theory. The most important postulates of this theory can be summarised in three axioms. The first axiom states that every observed test score (x) includes a true value (t, true score) which maps the constant expression of the distinguishing features of a particular person. According to the second axiom every measurement includes a degree of error (e, error score) which affects the measurements in a random manner, such that the arithmetic mean of all error scores is precisely zero. Axiom number three states that the observed test score x is composed of the addition of the true score t and the error component e to give $x = t + e$.

The classical test theory is abstract, because essentially it is nothing other than a collection of arithmetic predicates. Seen from the point of view of scientific theory arithmetic propositions say nothing about 'our world'. They are simply a game in which one plays with symbols. The fundamental difficulties pupils, students, parents, and teachers have with the interpretation of a test result are to be attributed to the fact that the theoretical language in which it is expressed is in an uninterpreted form. This can be demonstrated by looking at the example of the symbol for 'true'. According to SUTCLIFFE (1965) there are several different possible interpretations of the expression 'true'. One interpretation is the so called classical interpretation (for t) and another is the so called platonic interpretation (for t'). From the different interpretations one arrives at different methods for evaluating. In the case of the classical interpretation t and e are considered to be uncorrelated. In consequence the item variance is composed of the variance of the

true score and the error variance together according to $s_x^2 = s_t^2 + s_e^2$. In the case of the platonic interpretation on the other hand a connection between them is assumed so that for the item variance the covariance must be taken into account according to $s_x = s_{t'}^2 + 2\mathrm{cov}(t', e)$. The choice of an appropriate interpretation depends on the epistemological postulates. About these it is comprehensible that in accord with the aforementioned Munchausian Trilemma it is not possible to make a definitive decision.

Lastly Model Platonism also prevents the acquisition of an applied practice accompanied by rules. The classical test theory limits itself to the mathematical description of test methodology. It makes no claims to any connection to reality. When pupil A scores 30 points in an exercise, and pupil B scores 20 points and pupil C scores 10 points, then it is certainly possible to extract information about the relationship between the figures. One has scored more points than the others, three times as many as one of the others. However there are no rules according to which the meaning of the point scores can be explained above or beyond the meaning they have in the realm of figures. The limitation displayed by the classical theory also holds good for the probabilistic approach. The TIMSS studies and the PISA studies were conceived in order to provide a means of making international comparisons. However comparisons in the classical as well as in the probabilistic approaches are only given in reference to extensional equality and inequality, as shown by KROPE and WOLZE (2005, 92 seqq.) in an empirical study. Axiomatic theories fail to cover the intentional dimension.

3 The Up-To-Dateness of the Methodical Constructivism

In the following we will deal with an approach to relieving the crisis in which modern science finds itself presently. The basis is the Constructivism established by KAMLAH and LORENZEN (1973). In order to distinguish it from Radical Constructivism their position is denominated ‘Methodical Constructivism’. An encyclopaedic description is to be found in MITTELSTRAß (2004). A further development of this paradigm has been presented by HARTMANN and JANICH (1996, 1998) under the appellation ‘Methodical Culturalism’.

In contrast to the axiomatic sciences, in the Methodical Constructivism there is the requirement that the first steps in the construction of a scientific terminology should be accessible to rational argumentation. To this end the constructive scientific terminology is reconstructed from the ground up, in the process of which any correspondences with established scientific terminology are avoided. The starting point for the reconstruction is the prescientific everyday practice which is assumed as being unproblematic.

According to this principle terms such as the term ‘true’ can be introduced. This process is commenced in prescientific language with simple verbal and nonverbal acts. In an example of the demonstration of this method (carried out at length by KROPE 1988 as well as KROPE and LORENZ 1993) living beings were assigned words to describe them such as ‘docent’ and ‘tomcat’. These words were denominated ‘predicates’. This process is called ‘predication’. In predication through the use of proper nouns whole sentences are constructed such as ‘Max M. is a docent’ and ‘Fritz F. is a tomcat’. Such sentences are given the appellation ‘elementary phrases’. In the example with the docent and the tomcat the avoidance of misunderstandings is asked for, and that thereafter Fritz F. should not be described as a docent nor Max M. as a tomcat. This request is easily made understandable, as in the Federal Republic of Germany on legal grounds a tomcat cannot be a docent. The request can as follows, through the combination of two elementary phrases, be partially formalised: “Pass from the phrase ‘Max M. is a docent’ to ‘Max M. is a tomcat’’. If this is not contradicted and the request is followed in the fu-

ture (the request is harmless and there is really no obvious ground visible indicating why one should not accede to it) then through the correspondence of the two elementary phrases in connection with a generalisation, a rule is expressed according to which, within the context of the example, the two predicates 'docent' and 'tomcat' should be used. The rule goes as follows: if the first contention is not disputed then it is forbidden to dispute the second contention. This is only one of many rules and one which in addition is a simple rule. Rules such as these, with which the use of predicates is normalised, are denominated 'predicator rules'.

Those who in using the two predicates, probably through forgetfulness, fear misunderstandings, can doubt the validity of an assertion such as 'Max M. is a tomcat' and as a result pass to the attack. The attacker of an assertion is denominated an 'opponent', and the defender of an assertion is referred to as its 'proponent'. The defence of this assertion is not difficult for a proponent. Precisely because a rule is available for the assertion, a defence can be made against any opposition to it. Thus the opponent may agree: 'Oh yes! That's right!' In this case there is the agreed upon transition rule! The proponent has won the dialogue because he has successfully defended his assertion. 'Successfully' means: he has not 'somehow' defended his assertion, but rather he has been able to give a rule according to which it can be defended against any and all objections. With reference to everyday expressions such as 'Oh yes! That's right!' the questionable term is then introduced in multiple steps, in which first of all: an assertion, for the defence of which such rules can be given is called a 'true assertion'.

What consequences does the constructive introduction of language, done in the way that it was performed for the term 'true' have? The traditional and problematic conception of an appellation which is in itself and of itself comprehensible is no longer necessary. In the Methodical Constructivism calling on the discernment of the validity of assertions is replaced by the collectively assessable correctness of particular acts of language. Language has thus become a conceivable condition for the possibility of scientific knowledge.

In the following it will be shown in what way, using the Methodical Constructivism, it is possible to gain everyday applications from scientific assertions. To this end once again the example using the tertiary institution instructor Max M and the tomcat Fritz F will be taken up. In its characteristics the term 'true' was introduced with respect to a transitional rule. This introduction can be formulated as '$(E_1\ \varepsilon\ q \Rightarrow E_1\ \varepsilon'\ p)\ \varepsilon\ w$'. Here E_1 represents the proper name Max M, ε is the abbreviation for the copula 'is', with the apostrophe following the 'ε' the negative is expressed, p and q represent the predicates 'instructor in an institution of tertiary education' and 'tomcat', $\Rightarrow$ is the transitional arrow, and the letter 'w' the abbreviation of the term 'true'. If the proper name (E_1) is replaced by a variable for proper names (x), then one gets a generalisation, since the validity of the formula does not require and is no longer dependent on a particular proper name. This formula is no longer everyday language. With the term 'true' the formula belongs to the terminology of scientific language. Individual living things are no longer explicitly named but rather they are taken up (quasi-anonymously) in a zone of variability. In this continuation of the example involving the instructor in a tertiary institution and the tomcat it must be crystal clear, in so far as the question of interpretation of scientific assertions is about a problem of the relationship between the particular and the general. This relationship will be described in the following paragraph.

In the Methodical Constructivism the general is determined in three stages. Firstly the general is valid as mode of action having the characteristics of repeatability and reproduction. KAMLAH and LORENZEN (1973, 57 seqq.) mention this determination in the example of the driver of a car, who signals an intended change of direction through the use of his car's indicator lights. Such acts are denominated 'indicator actions'. Under-

standing them relies on an agreement, as does the meaning of the indicator lights which is also explicitly agreed and laid down in the legislation governing the use of public roads. With the agreement and the acquisition of practice the indicator action becomes an indicator mode of action.

The general as mode of action for the same, that through abstraction is acquired out of what different, is regarded as the second stage in the constructive determination of the general. Thereby abstraction is denominated as that procedure by which one subtracts everything which differentiates two expressions from them, and concentrates only on that part of them which can be equated. What was said about sameness and differentness applies equally to individual words as it does to individual assertions. Thus in the sentences 'Mr. B. slew his wife.' And 'Mrs. B was slain by her husband' both the sameness as well as differentness of the two sentences can be the object of our concentration. The first sentence is formulated in the active voice and the second sentence is formulated in the passive voice. In so far as the difference in formulation between the two sentences is substantiated by the fact that the first sentence places the murderer and the second sentence places the victim in the foreground, difference is manifested. If one ignores this difference however it can be said that sentence 1 and sentence 2 are the same. Sameness is 'Sameness with respect to something'. Firstly what is different is equated, in that ones attention is directed only to particular parts of their content.

Repeatability and sameness are the first and second stages of the general. They presuppose and require a third stage. If many individual objects are always only the same from a particular point of view, then the question of their generality becomes a question of the point of view from which predication succeeds. For this reason, always assuming that it is legitimate, the goal which those who are predicating are pursuing, is finding a yardstick for the evaluation of sameness and difference. In the sentences 'Mr. B slew his wife.' and 'Mrs. B was slain by her husband.' it may be sameness or difference depending on what the purpose of the expression is.

What consequences does the constructive determination of the general have for the question of finding a rule based acquisition of scientific assertions for everyday practice? Three stages provide a statement of the requirements for those rules according to which the general is formulated. These are the rules for the explicit agreement and the exemplary practice of predicates, the rules for the transition from sameness to difference and the rules for the choice incumbent on the predicator of a standpoint from which to articulate the aims which they are pursuing with an assertion. The rules are necessary conditions for the formulation of a general. They are to be observed if in the inverse case the particular of a general is enquired after. In an empirical study on the contentedness of youths KROPE et al. (2002) accordingly and comprehensibly were able to ascertain the delineated relationship between the particular and the general in that they were able to find consequences in a concrete form for the youths questioned.

4 Learning to Carry out Research in Educational Science

In what preceded it was demonstrated that if the model platonic conception of science is followed then any conceivable reference to practice in the every day life is impossible. The consequences of this scientific concept could be demonstrated in an empirical investigation as was exhibited by KROPE and LORENZEN (1993). The subject of the study was pedagogical self-comprehension in Germany. The question to be cleared up was whether education needed to be dogmatic (KROPE 1997). In the study around 1,300 pedagogues from all over the entire German Federal Republic were included. Among other things dogmatic attitudes and scientific abilities with respect to the following edu-

cational institutions: technical schools, technical universities, teacher training colleges, and universities.

The definition of 'dogmatic' refers to the term 'dialogical' which is introduced in the Methodical Constructivism. The term 'dialogical' summarises the possibility which is developed in Constructivism to determine the truth or falsehood of assertions in a dialog between its opponents and proponents. The term 'dialogical' was broadened in the following way: 'T-dialogical' (with 'T' for 'Text') was what the dialogical behaviour of a particular person was, with reference to their way of dealing with a particular text, if there is any question as to the truth of a particular assertion. According to this definition people who do not deal with pedagogical texts dialogically, if it is a question of truth, are dogmatic. In order to empirically investigate 'dogmatism' surveys were carried out using tests to discover if the pedagogues involved would accept untested propositions which unconditionally demanded validation, as true.

In a further segment of the study scientific knowledge and accomplishments were investigated once again by means of tests. As a yardstick of scientificness three areas were laid down, of which it was assumed, that they implied a greater number of scientific opinions among the academics. These were abilities in the areas of empiricism, hermeneutics, and logic.

The most important result in the framework of the topic under discussion concerns the relationship between scientific education and dogmatic attitudes. For both characteristics a significant negative correlation was established. This finding can be summarised as a hypothesis in the following way: the smaller the scientific content of the education of pedagogues, the more dogmatically they think as a rule.

In the study it was shown, that as a rule averagely dogmatic thinking moving from the technical school, through the technical university and the teacher training college through finally to the university tended to be of a decreasing magnitude and that similarly average scientific ability in the same sequence increased from the beginning to the end of the series of institutions. In the following table this relationship is reproduced for the two institutions that held the positions at the beginning and end of this ranking. Seen from the viewpoint of practicality the result can be interpreted, taking into account the curricula of the specific institutions, in the following way: the closer an education is to the applied practice of the everyday life, the more dogmatic overall it is and the more academic an education is, the farther it is from the applied practice of the everyday life. The results of the study identify an institution specific separation between the forms of education. This highlights the fact that at the present time education is either on the one hand more oriented towards everyday practice or on the other hand more oriented towards theoretical science. This either…or… separation reflects the weakness of the currently dominant understanding of model platonist science as previously described.

Characteristic	Institution	$\overline{X}$	N
Dogmatic Attitude	Tech.School	7.95	353
	University	7.09	563
Scientific Ability	Tech.School	2.33	325
	University	3.48	524

Dogmatic attitude as well as scientific ability in relations to the educating institution: $\overline{X}$ = arithmetic mean of the number of answers referring to the measured characteristic; N =number of subjects taking part (source: KROPE 1997, 305).

According to a classification which LORENZ (1979, 1980) undertakes in the Aristotelian tradition, two aspects of science which are inseparably bound up with one another can be described by the Methodical Constructivism. These are the aspects of research and

the aspect of representation. With the term 'research' LORENZ denotes that aspect of scientific activity, with which 'the procedure to *determine the meaning* of predicative expressions and thereby the *knowledge* (study) of the object' is worked out (LORENZ 1980, 663). Science in its research aspect is according to LORENZ a theory of objective competence. 'Representation' is in the demonstrations of LORENZ that aspect of scientific activity that 'aims at the procedure for *ensuring the validity* of assertions and therewith aims at the *description* (study) of the object examined.' (LORENZ 1980, 663). Science in its representational aspect is according to the author a theory of metacompetences. The connection between the two aspects is represented according to LORENZ thus, that firstly research as objective competence without the accompanying metacompetence is not communicable. Secondly representation as a metacompetence is dependent upon objective competence, because otherwise the suspicion of meaninglessness threatens to overwhelm the linguistic means' (LORENZ 1980, 664, more complete LORENZ 1979).

According to the methodical constructive understanding scientific education includes the acquisition of an activity in research objects and the acquisition of a representation of an object that has been researched as well as and including the acquisition of objective competence and the acquisition of metacompetence. The classification of science undertaken in the Logical Empiricism and the Critical Rationalism which divides it into 'context of discovery' and 'context of justification' envisages the second aspect of science. 'The modern nexus concocted by H. REICHENBACH under the titles discovery relationship/foundation relationship is more specialised and in both cases refers to the validity of assertions, namely with respect to the differentiation of inductive from deductive methods, and thus belongs to the theories of metacompetence, without however bringing up as a topic the problems bound up with the constitution of the objective area of objective competence' (LORENZ 1980,664). For this reason the research aspect of education has a low priority in the currently dominant concept of science. The stress is placed on the representational aspect of science. The findings which KROPE and LORENZ (1993) report, on the relationship between dogmatic attitude and practicality, are indebted to this dominant understanding of the nature of science. 'Dogmatic' means in this interpretation that that which is presented is perceived as meaningless and unquestioningly accepted, because a comprehensible reference to the represented objects cannot be provided.

In what preceded it was demonstrated that to have knowledge of particular you always have to refer on general. Validity of the general can be justified by a common participation of the speech- and communication community. Correspondingly is the perspective of students as participants in the scientific communication in an objective-level as well as in a meta-level not to circumvent!

5 Summary

The starting point of this contribution was the introduction of bachelor- and master-degree courses of studies in university education. What was sought after was a criterion for the evaluation of the reform measures. To this end the question of the form that such an education should take was raised. It must fulfil the demands of both being scientific and practically applicable. The answer to how this should be achieved was given based on the Methodical Constructivism. Against this background scientific education has two aspects: learning to do research and studying the researched objects representations. The methodical constructive conception of scientific education offers a yardstick for the evaluation of the bachelor- and master-degree courses. The paradigm is chosen as a

programme for the undogmatic, non-circu- lar, and comprehensible introduction of a conception of science, which serves to underpin practice in the everyday life.

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