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ABSTRACT

The application of a scientific attitude to the field of education is reviewed, with particular regard to the varying perspective concerning the cognitive development and learning processes of children. Flaws in the "top-down" system of research and information dissemination, in which universities are viewed as "producers" and practitioners as "consumers," are examined. The practice of implementing educational objectives in curriculum development plans is questioned, and discussion of a pluralistic view of teaching methods is presented. The conclusion is drawn that the science of education contributes significantly to the development of data relevant to improved teacher education. (LH)

SCIENCE OF EDUCATION AND TEACHER EDUCATION

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SCIENCE OF EDUCATION AND TEACHER EDUCATION

Introduction

For the past ten years there has been a lot of interest in teacher education throughout the Western world. In most countries reform plans were developed and to a certain degree implemented. In a sense this trend parallels the growth of the educational sciences, which has led to high expectations as to their possible contribution to the innovation and the optimization of school education. Already now there are signs of disillusion however. Some people only feel that the expectations ran too high, but others doubt the possible impact of the actual science of education on school practice. This contraposition also exists in connection with teacher education. For some teaching is an art and hence it can only be acquired through experience. Although the gist of this viewpoint is certainly true, we are convinced that a science of education can contribute substantially to teacher education. In this respect we agree with a recent statement by Gage (1978, p. 18) : "In teaching, where the artistic elements are unquestionable, a scientific base can also be developed". In this paper we will give some arguments supporting this position.

Some faulty contra-arguments

One of the findings of a recent investigation on the cognitive processes underlying pre-interactive and interactive teaching behaviour is, that the teachers studied in this project, do not function psychologically according to current models of the teaching-learning process as they can be found in most current textbooks on educational psychology (Lowyck, 1979). Such a finding could be used as an argument against the use of these models in teacher education. However, it is not a valid argument, because the teachers concerned were never trained to use such model as a guide for planning and carrying out their instruction. Stated more generally, the value of concepts and principles set forth by educational sciences cannot be refuted by referring to existing practices that are not based on these principles in the first place.

Many of the present doubts about the possible impact of educational sciences on changing and improving practice find their origin in the rather negative results of the RDD-strategy (Research, development and diffusion strategy). As it well-known this strategy, borrowed from industry and agriculture, represents a top-down model of innovation. Research is done at the university; on the basis of research results educational materials are developed; and finally the products of this developmental work are disseminated in practice. Bush (1975, p. 9) the former director of the Center for Educational Research at Stanford, has commented on this strategy as follows : "One serious defect in the old system was that the university was considered to be the producer, and the school the consumer, of research. Unfortunately, this pattern did not work satisfactorily for a variety of reasons : partly because the research was not useful, partly because it has not been translated into a form that was helpful, and partly because the users had not been adequately considered in the designing of the materials". However, the fact that this strategy failed is no reason to throw the useful content of a science of education also overboard. Meanwhile other strategies have been set forth, which take better account of the specific features and the complexity of the school world.

A final argument relates to the recurrent conclusion of research reviews that the results of a series of studies are contradictory and inconsistent. This applies in particular also to research on teaching. Referring to examples of such reviews, Gage (1978, p. 24) writes that the conclusion mentioned above is often drawn overhasty. He demonstrates that a more thorough analysis and a combination of the results of a number of investigations can yield more consistent trends. Besides at the 1979 meeting of the American Educational Research Association in San Francisco, Glass stated that one should not be astonished about inconsistencies in the results of educational research; the contrary would be rather surprising. Education is an unpredictable system, a statement that also holds for other systems like the weather. Because the system will always be predictably unpredictable and consistently inconsistent, part of the variance will remain unexplained. Nevertheless good research continues to be a meaningful enterprise and, as is also the case for meteorology, it can yield relevant and useful data. On the other hand it is necessary to develop a policy to manage the unpredicted.

Teaching : an activity of design, interaction, and cooperation

Educational research, during almost two thirds of this century, concentrated on learning. It was only in the sixties - partly due to the failure of learning research - that teaching began to receive more interest (Gage, 1963). In line with the scientific tradition inspired by behaviourism, the first studies were focused mainly on the observable behaviours of the teachers during their interaction in the classroom. A lot of observation instruments have been constructed for that purpose (Rosenshine & Furst, 1973). The pre-interactive phase of teaching was largely neglected. During this phase teachers do their planning and preparation; in other words they design their instruction. Only recently research is also giving attention to this important category of teaching behaviours (Gagné & Briggs, 1974; Gage & Berliner, 1975; Lowyck, 1979).

In the school practice of every day the classroom mostly is still an island, where the teacher is the sole master in his little kingdom. The term self-contained classroom expresses this very well. This situation strongly contrasts with the present conception of teaching resulting from innovation-projects and research on educational change, namely that teaching should be teamwork which takes place in the specific organizational context of the school. It can be taken for granted that in the near future the cooperative and organizational aspects of teaching will become more and more important in the teacher's task; teacher education will have to take this into account.

In summary, we conceive of teaching as comprising two stages : a pre-interactive and an interactive phase; it takes place in a specific organizational context, wherein cooperation should be an essential feature. The science of education can be helpful in preparing teachers for this complex task. This view is supported by the following arguments, which will be illustrated further in this paper. (1) The science of education offers research-based concepts and principles, that are relevant and useful for teacher education. (2) There are examples of innovating projects that demonstrate the positive contribution of educational knowledge to the improvement of teaching behaviour.

Relevant educational concepts and principles

Overviews of educational research often end with the statement that the field is still in its infancy. It is a pity, but we can only endorse this statement. Nevertheless the educational sciences contain a number of relevant

data, and it would be unjustified to neglect them in teacher training. We will illustrate this with some examples.

Stating educational objectives.

The desirability of stating educational objectives has been a controversial issue in the recent literature relating to curriculum planning and instructional design. The research data with regard to this topic are not always cogent and consistent. Nevertheless, from a recent analysis of the available studies, Davies (1976, p. 95) rightly concludes that objectives can be useful in the design of instruction and of curricula, and that it is therefore desirable to train teachers in working with educational objectives. The functions of objectives can be diverse. They are orienting stimuli in connection with the selection and development of instructional methods and materials, and also with regard to the construction of evaluation instruments. Furthermore, clearly stated objectives can promote good communication and cooperative planning and in this way they can contribute to a more systematic longitudinal planning of instruction over teachers and grades.

Of course there also are some dangers to working with specific objectives; because they are probably well-known, we will not discuss them here. However, these dangers are real only if one interprets the principles of specifying objectives in a narrow and rigid way. Therefore we would like to warn against any dogmatism in this respect. The specification of objectives should be applied in a flexible way as an aid in instructional planning and not as a goal in itself. Not all objectives can and should be stated in Magerian terms (Mager, 1962); more open types of objectives can be equally useful and orienting. Besides, it is our opinion that for the past ten years too much attention has been given to techniques for the formulation of objectives and not enough to the derivation and legitimation of goals (De Corte e.a., 1974; De Corte, 1975). This seems to be changing now and with respect to teacher education it is extremely important to prepare teachers so that they can participate actively and constructively in discussions about desirable objectives of instruction. This position is also supported by recent research on time allocation to curriculum activity (Bennett, 1978). These studies show that the knowledge pupils acquire depends on the coverage and the emphasis in the curriculum. Decisions concerning these matters are considerably influenced by the objectives adopted. Therefore Bennett (1978, p. 137) concludes : "Clearly, teachers and student teachers should have, or be given, the necessary knowledge and conceptual skills to think clearly and critically about aims and their relation to practice and possible outcomes".

Modifiability of learner characteristics

One of the leading ideas of educational innovation today certainly is that instruction should be adapted to the individual learner (Glaser, 1977). According to recent research this does however not mean that instruction should only be linked up to the factual status of the learner's aptitudes. On the contrary there is a lot of evidence now that learner characteristics should not be seen as static and consistent traits, but as modifiable entities subject to instructional influence. This has been especially well demonstrated with reference to cognitive development, in Western research (Sigel & Cocking, 1977; Case, 1978) as in investigations in the Soviet Union (De Corte, 1977c). Because the Russian studies are probably less well-known, let us use them as an example.

The basic idea of the research is Vygotsky's conception of cognitive development, that distinguishes the zone of nearest development from the level of factual development (Vygotsky, 1963). While Piaget considers development as the basic process which is almost independent of learning (Piaget, 1971), Vygotsky takes an opposite position. According to him learning plays an important stimulating role in development.

The level of factual development consists of all those behaviours which a child can independently perform correctly; this level of factual development is measured by traditional intelligence tests. However, the child is able to achieve more than that, if it receives the necessary help from adults. Those behaviours which a child cannot perform independently, but can with assistance, constitute the zone of the nearest development. Instead of linking up instruction to the level of factual development, one should orient it to the zone of the nearest development. This means that instruction should : (1) help the child to master independently the behaviours which constitute this zone at a given moment, (2) stimulate cognitive development by continually creating a new zone of the nearest development.

Research undertaken by Gal'perin and his associates has produced evidence for Vygotsky's position that instruction can influence cognitive development. More specifically some investigations have demonstrated that Piaget's interpretation of the well-known facts on conservation becomes untenable (Van Parreren & Carpay, 1972, p. 69-77). The general finding in itself is useful for teacher education, because it refers to the plasticity of human characteristics. But there is more. In these studies Gal'perin has applied his stage-by-stage procedure of learning, which can be a very useful guide for the design of instruction in connection with different kinds of objectives, esp. the learning of basic concepts and rules. This brings us to another body of information which is useful for teacher education.

Knowledge about children's learning

In the literature it has often been stated that the tremendous amount of learning research of this century has not yielded very many results, which are relevant and useful with regard to learning in schools (Hilgard, 1964). This statement is certainly true, but one must admit that nowadays the scene seems to be changing slowly. This has to do with two trends. (1) Educational psychologists have become aware of the fact that relevant data can only be obtained if learning is investigated in real educational settings. Data from laboratory studies cannot be generalized towards the classroom, because the experimental situation lacks external or ecological validity (De Corte, 1979). (2) The rise of cognitive psychology has led to a shift from the behaviouristic towards the information processing approach of learning, which seems more promising with respect to understanding and stimulating learning in school settings (Lesgold e.a., 1978; Glaser, 1978). A European view that parallels this American approach originates from Russian psychology. It also rejects a solely performance-oriented approach and takes as its central object the actions of the learner. If learning is to take place, it is necessary to influence the person's actions. From the performance of actions certain capabilities arise as learning outcomes. The research of Galperin, whose work was already referred to, is representative of this view. In the Netherlands and Belgium this approach has been introduced by Van Parreren (1978; 1979).

There remains a lot of research to be done relating to this important domain of children's learning. Nevertheless some interesting data have already emerged during the last few years. Again we can only briefly illustrate this statement.

One example is related to an important objective of education today, namely learning to think (De Corte, 1977a; 1977c). When one looks at educational practice learning to think seems to be viewed implicitly as aquiring conceptual subject matter content (such as concepts, rules, principles). This is in line with the strong orientation of teachers towards the content aspects of instruction. Older as well as more recent research, again from Western and from Russian origin, demonstrates that this is too limited a view of learning to think. The "contents of thinking" represent of course an important aspect of it, but equal attention should be paid by the teacher to thinking methods. Teachers often use and apply spontaneously all kinds of heuristic procedures during their instruction, but they omit to make them explicit and to teach them deliberately to their pupils. The result is that pupils are not able to cope with the problems even when they master the necessary content

to solve them; the reason is that they lack thinking methods to analyze and transform problem situations, so that it becomes clear how the available content should be used to reach a solution. This is again a well documented finding and certain studies demonstrate that by teaching thinking procedures to pupils their problem solving performance increases significantly (Van Parreren, 1975).

A second illustration relates to a finding mentioned earlier, namely that there is a relation between time allocated to a curriculum activity and the knowledge acquired by pupils. Further analyses have shown, as can be expected, that achievement correlates even stronger with active learning time, that is the proportion of the allocated time that is effectively used to study a given content (Bennett, 1978). This variable is also referred to as time-on-task or academic learning time. One investigation that has yield evidence for the relation between active learning and achievement is the American "Beginning Teacher Evaluation Study" (Fisher, Filby, e.a., 1978; Fisher, Berliner, e.a., 1978). Obviously the research result concerned has important implications for teacher training. Teachers should be permanently aware of this relationship and their efforts should be directed towards a high level of active learning time. This is mainly a question of classroom management. Time spent on unproductive activities, such as transition from one learning activity to another, distributing and collecting tests and other materials, dividing the class in small groups, etc. should be decreased.

A pluralistic view on teaching methods

In the past a bulk of educational research was done on the comparison of teaching methods. Aside from the methodological problems of this research, the guiding idea of finding one or some superior methods was a mistake. In educational practice on the other hand the situation also was and often still is characterized by a unitaristic and one-sided view. In a lot of schools lecturing or a variation of it remains the prevailing method, while innovative schools pin all their faith to one or another so-called modern device, e.g. the project method.

Nowadays their is sufficient evidence to support a pluralistic view of teaching methods. The question is not : "which method is the best one ?", but "for what kind of objectives is this method appropriate ?" This implies a very important principle for teacher education, namely that teachers should be trained in the flexible use of a variety of methods (Gage & Berliner, 1975).

At present research on teaching is less oriented toward the study of global teaching method and more toward the analysis of specific variables and dimensions of teaching behaviour. We already mentioned that reviews of this research area often conclude that the results are inconsistent. As said earlier, according to Gage, this conclusion is drawn overhasty and meta-analyses of the investigations concerned can yield more consistent findings. With his associates Gage carefully analyzed several major studies, that correlated specific variables in teaching behaviour with pupil achievement. From the findings of these studies he derived so-called "teacher-should" statements, i.e. "inferences as to how third-grade teachers should work if they wish to maximize achievement in reading and, we think, also in mathematics, for children either higher or lower in academic orientation (Gage, 1978, p. 38). The 22 statements relate to : behaviour management and classroom discipline, instructional methods, and specific methods for asking questions and providing feedback (Crawford & Gage, 1977). Although these statements are interesting in their own right, they can be criticized for several reasons. First of all they are not situated in a broader frame of reference and as a consequence they lack coherence. Moreover the list illustrates remarkably well that in a lot of studies the planning phase of teaching was neglected; the statements relate only to the interactive phase of teaching. These criticisms were largely met in the earlier mentioned "Beginning Teacher Evaluation Study" (Fisher, Filby, e.a., 1978; Fisher, Berliner, e.a., 1978).

This study developed and tested a model of the teaching-learning process. According to the model certain instructional processes lead to student learning, which results in achievement test scores. The instructional processes component of the model is specified in terms of five different but interrelated instructional functions, namely diagnosis, prescription, presentation, monitoring, and feedback (Fisher, Berliner, e.a., 1978, p. 5). Diagnosis and prescription constitute the planning phase or pre-interactive phase of teaching. Diagnosis refers to the assessment of the initial level of the student's knowledge and skills. Prescription implies the establishment of appropriate goals and the design of instructional activities to achieve them. These decisions set the stage for the interaction phase, which begins with the presentation of information or a learning task to the student. The teacher monitors the student's reactions to this input in order to know whether the instructional goal is being achieved. Monitoring tells the teacher about the student's state of knowledge or skill following an instructional activity. On the basis of this information, the teacher may provide feedback to the student, provide additional explanation or cycle back

to the beginning for further diagnosis and prescription. The model implies that these five functions occur in a cyclical pattern and that each of them can be accomplished by a number of different behaviours. "The same behaviours may serve different functions and different behaviours may serve the same function, depending on the context" (Fisher, Berliner, e.a., 1978, p. 39). The empirical verification of the model in twenty-five classes of grade two and twenty-one classes of grade five, led to nine interesting findings on the relationship between teaching processes and student learning. As an illustration we cite three examples.

"The teacher's ability to diagnose student skill levels is related to student achievement and academic learning time" (Fisher, Berliner, e.a., 1978, p. 14).

"The teacher's ability to prescribe appropriate tasks is related to student achievement and student success rate" (Fisher, Berliner, e.a., 1978, p. 14).

"Academic feedback is positively associated with student learning" (Fisher, Berliner, e.a., 1978, p. 16).

These findings are important in their own right. However they become even more significant because they can be interpreted within the functional view of teaching presented in the model. In this connection Fisher, Berliner, e.a. (1978, p. 39-40) write : "Certainly teachers need a repertoire of specific teaching behaviors, but they must also have a good grasp of the functions that specific behaviors fulfill in a given context. Teachers who are aware of teaching functions will be able to conceptualize their classroom behavior in terms of this more general framework. They will be able to evaluate what they are doing in terms of instructional functions that should be served. Furthermore, they will be able to recognize what they are not doing, in terms of functions that are not served by any of their usual behaviors." The importance of these conclusions for teacher education is self-evident.

The preceding does, on the other hand, not imply that present research on teaching has no weaknessess. Shortcomings can be overcome however and they are not a sufficient argument to conclude that research on teaching behaviour is useless. An important and necessary change in future research is that more attention should be given to the underlying cognitive and affective variables of teaching behaviour. Past studies have, in line with the prevailing research paradigma, concentrated too much on observable behaviour; that is also true for the "Beginning Teacher Evaluation Study". However, overt behaviours

can only be understood and interpreted in terms of the underlying internal processes which determine them. Insight in these processes will be an important base for the identification of skilled teaching behaviour. An example of such a process-oriented study was refetred to earlier in this paper (Lowyck, 1979).

Principles of educational evaluation

Evaluation is generally considered an important aspect of the teacher's task. He or she should be able to design appropriate evaluation instruments, and to interpret and use the information acquired to improve the teaching-learning process. The present state of research on educational evaluation offers a lot of useful concepts, principles and techniques, which can be very helpful for the teacher. We will only briefly mention some general basic ideas (Bloom e.a., 1971; Popham, 1974; Walberg, 1974).

- Because of the variety of educational objectives pursued by the school, a comprehensive system of evaluation will require a variety of evaluation methods. Indeed different categories of objectives, e.g. knowledge, skills, and attitudes, will need different assessment techniques.
- As far as achievement testing is concerned the concept of criterion-referenced tests has been introduced. It refers to an "educational" type of instrument as opposed to the traditional norm-referenced tests, which are based on psychometric principles. Norm-referenced tests are designed largely for purposes of prediction and selection; therefore they describe an individual's performance in terms of the relative position he holds in a well defined group of individuals. However prediction and selection are not the primary goals of a teacher. His main concern is to know the degree to which each learner has attained a criterion performance.
- To guarantee the continual progress of learners it is necessary to build in formative evaluation in the teaching-learning process. By this we mean a system of diagnostic progress tests to control the mastery of a limited set of objectives before starting to work on the next unit of instruction.

We have reviewed a selection of positive data obtained by educational research, which are useful in view of teacher education. Let us add that one can often also benefit from negative results. E.g. studies have shown that grouping children in smaller classes does not necessarily produce superior achievement (De Corte e.a., 1974, p. 288-289). It has been established that teachers in smaller classes often behave and teach as before and that they do not exploit the opportunities for more individualized instruction offered by the small group.

The findings mentioned above are only illustrative. Together with other relevant data they can be ordered in models of the teaching-learning process, giving an overview not only of the components of this process, but also of the relations and interactions between the components (see figure 1). It is our experience that such a model is very useful as a frame of reference for the teacher's planning and action, and also for the reflection on this planning and action. Of course the model should be used in a flexible way rather than become a rigid strait-jacket. It should have a heuristic and orienting function.

Insert figure 1 here

Evidence from innovating projects

During the past decade a number of developmental projects designed to innovate school education in some respect have provided evidence that the science of education can contribute to teacher education. We wish to illustrate this argument by referring to three projects.

In the first place we discuss Individually Guided Education in the U.S.A. Then we provide concise information on a curriculum development project in Belgium and one in Russia based on Gal'perin's learning theory.

Individually Guided Education (IGE)

IGE is one of the state-wide projects of individualized instruction in the U.S.A. It has been developed at the Wisconsin Research and Development Center for Individualized Schooling (Madison, Wisconsin) since 1965. Klausmeier (1975,p. 48), the stimulating leader of IGE, characterizes the project as follows : "a comprehensive alternative system of schooling designed to produce higher educational achievements by providing for differences among children in rate of learning, learning style, motivational level and other characteristics". The seven components of an IGE school are :

(1) a new set of organizational-administrative arrangements and processes;
(2) instructional programming for the individual student;
(3) evaluation of student learning tied to instructional programming for the individual student;
(4) curriculum materials compatible with instructional programming for the individual student;
(5) a program of home-school-community relations;
(6) facilitative environments in the school district and state to support IGE practitioners;
(7) continuing research and development to keep IGE attuned to changing societal conditions.

According to Klausmeier (1977, p. 7) "the two key components of IGE as a new kind of schooling are instructional programming for the individual student and the organizational-administrative arrangements that make it possible".

The organization for instruction is called the Instruction and Research Unit; it replaces the age-graded self-contained classroom. A unit includes a unit leader, 3-5 staff teachers and 100-150 students; the age range of students within a unit can vary from 2 to 4 years. Other persons who can be included are : an instructional aide, a clerical aide and a student teacher. The main functions of the cooperative instructional team are to plan, carry out, and evaluate instructional programs for the individual students of the unit. Mutual contact and shared decision-making are basic to the work of each unit. This requires that teachers are prepared and trained to function adequately in this new conception of their task.

In the IGE Teacher Education Program techniques for staff development and for establishing a positive climate in a unit have been developed (Nussel, Inglis & Wiersma, 1976). They are intended to train teachers to cooperate effectively with others within the specific organizational context of IGE.

The organizational context allows for a more individualized system of education. The central component of IGE however is the model of instructional programming for the individual student shown in figure 2 (Klausmeier e.a., 1977). The headlines of the model are comparable with the model of the teaching-learning process which was presented earlier in this paper. The model is used by IGE teachers as a frame of reference in planning, implementing, and evaluating their instructional programs. It has also been used as a guideline for the construction of IGE curricula in mathematics, in reading, in science and in social studies (Klausmeier e.a., 1977). IGE teachers are trained in working with the model and with the curriculum materials based on it. However these materials are not compulsory in IGE schools, but they are merely offered as examples of how individualized instruction according to the IGE principles can be elaborated. For the rest each school is itself responsible for its instructional programs.

Insert figure 2 about here

Evaluation studies relating to IGE in general have yielded positive results (Klausmeier, 1975 and 1977; Klausmeier e.a., 1977). The model for instructional programming seems to be a useful guideline for teacher planning and teachers in IGE schools feel that they are involved in making relevant instructional decisions.

In a recent conversation with Miles, one of America's experts in educational evaluation, he told us that IGE is one of the succesful innovative projects in the U.S.A. According to him this is due to the fact that in IGE attention is given both to the organizational aspects of instruction, and to teacher training and the content of the instructional programs.

This short presentation of IGE contains evidence that a science of education is a powerful source of ideas for teacher education. Teachers can be trained to work flexibly with a model of instructional programming. On the other hand available principles of groupwork and organization development can be applied succesfully to prepare teachers to function appropriately as members of a cooperative instructional team.

Two curriculum development projects

In line with the conclusion drawn from IGE several other projects also provide evidence for the position that teachers can learn to work effectively with a model of the teaching-learning process.

In 1968 a new section was started as part of the traditional system of secondary education in Belgium (De Keyser & Jaspaert, 1974; Jaspaert & De Neve, 1975; De Corte, 1977b). The section was named 'human sciences' and its focus is placed on social and behavioural knowledge, abilities, skills, and attitudes. The development of the curriculum for the new section was undertaken as a cooperative enterprise between a research team and all the teachers of the 17 schools wherein the section was started. Two basic principles of the curriculum development model were the following. (1) The model is objectives-oriented as opposed to the traditional, content-oriented approach. (2) The curriculum development took place in a democratic way as opposed to the traditional centralistic approach. This means that the project kept aloof from the classical RDD-model. The curriculum was developed by the teachers themselves under the supervision of the research team.

At first the teachers seemed to be strongly content-oriented in thinking about their teaching. Teacher training was therefore aimed at getting them acquainted with the objectives-oriented model of the teaching-learning process that was taken as basis for the curriculum development. This goal was succesfully accomplished. Together with the teachers a global curriculum plan and a series of teaching-learning units were constructed. These units are exemplars of the curriculum development model. They contain : a set of specific objectives, specifications concerning related instructional content and methods, possible evaluation techniques, and annotated references to materials for further information and study.

Earlier in this paper we already referred to Gal'perin's theory of the learning process. Based on this theory, which we cannot explain here, a lot of curriculum development work has been done in Russia, especially in connection with language and mathematics instruction in the primary school. The curricula are elaborated in narrow cooperation with teachers of the schools where they will be tried out. The cooperating teachers are very enthusiastic about this procedure; they find it stimulating and instructive (Van Parreren & Carpay, 1972, p. 87-88).

Summarizing the preceding information, it seems not only possible, but also worthwhile to train teachers in working with models of instructional design, which order and integrate concepts, principles and methods of the science of education in a systematic way. In addition it is very desirable that teachers learn to work with available curriculum materials based on such models. We mean in this respect that is is necessary for teacher students to study and use different types of materials, e.g. more structured and guiding curricula on the one hand and more open examples of the self-discovery type on the other hand.

From the IGE-project we have also learned that teacher education can profit from available data and methods relating to groupwork and group processes and from techniques of organization development. This last source of relevant data is relatively new, but will probably become more and more important. It can indeed be predicted that team teaching and flexible organization will be central features of future schools.

Concluding statements

We have tried to demonstrate that the science of education offers a lot of data relevant to the development of teacher education programs. In doing so we have not yet considered all the subdomains of the science of education. E.g. research on teacher education itself has also been developing strongly during the recent past and the trend toward professionalization has been substantially influenced by this field of research. An important area of study within this subdomain relates to the training methods, such as microteaching, minicourses, interaction analysis, case studies, simulation, and role playing. We will not discuss this topic in detail here, but limit ourselves to one remark. The problem with these techniques is that they were often used in a unitaristic and isolated way. E.g. microteaching is not the only true faith, which is appropriate for training all teaching skills. Furthermore if student teachers have learned in a microteaching situation to ask questions which stimulate higher-order cognitive processes, this skill should afterwards be transferred and integrated in their normal classroom teaching behaviour. It is our

opinion that the available methods and techniques can all contribute in some respect to the professionalization of teacher education, but they should be reconsidered as to determine their relative value and their appropriate place in a broader training program.

Our point of view that the science of education can contribute substantially to teacher education, does not imply that we would advocate the construction of a directive and closed type of curriculum based on these data. On the contrary each program should leave the necessary space for experience-based, discovery learning by the student teacher. It would be uneconomical however not to make use of the available results of the science of education; moreover, this would consolidate the well-known and often regretted gap between theory and practice. Further, we would like to warn against the position that the formation of creative teachers is rather hindered by the acquisition of educational knowledge and techniques. We agree that good teaching is a creative activity and that in teacher education creativity should be stimulated. However recent data point out that two basic conditions for creativity in a given domain are : the presence of a broad knowledge-base on the one hand and a strong motivation on the other hand (Hayes, oral communication). It seems to us that the science of education can provide the necessary knowledge-base, and if this takes place in an appropriate way, it can also have a stimulating effect on the motivation of future teachers.

As to the construction and implementation of curricula for teacher education, this should not be done according to the RDD-strategy, but as a cooperative enterprise wherein curriculum developers, teacher trainers, teachers and teacher students themselves participate. All interested groups have to take part in the decision making processes. The output should not be presented as a "must", but rather as a model showing how it "can" be done. Finally it is very important to evaluate the curricula after their implementation. In this connection new research data as well as practical experience should be used as data sources. On the base of the information gathered the programs can continually be revised and improved.

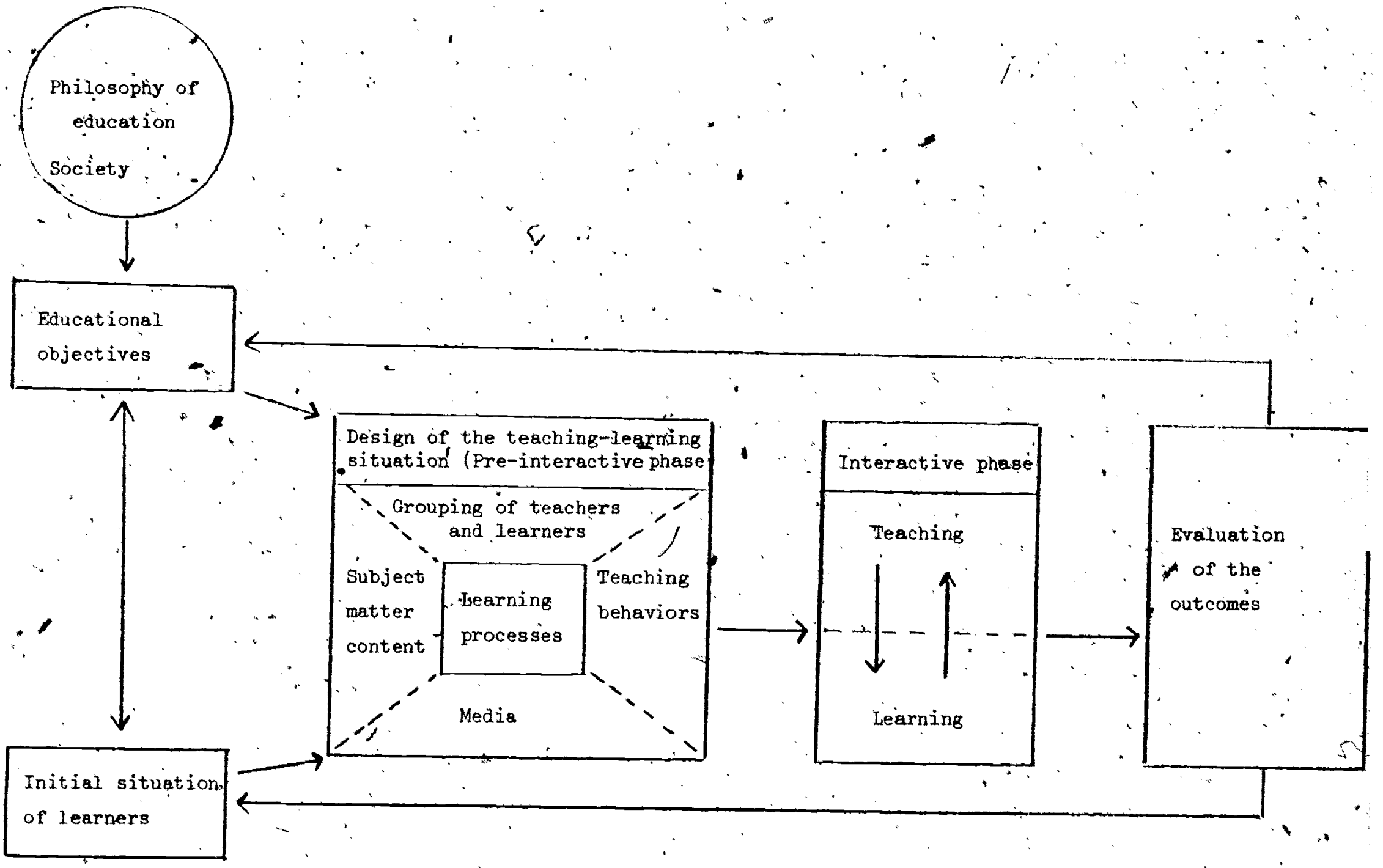

Figure 1. Model of the teaching-learning process

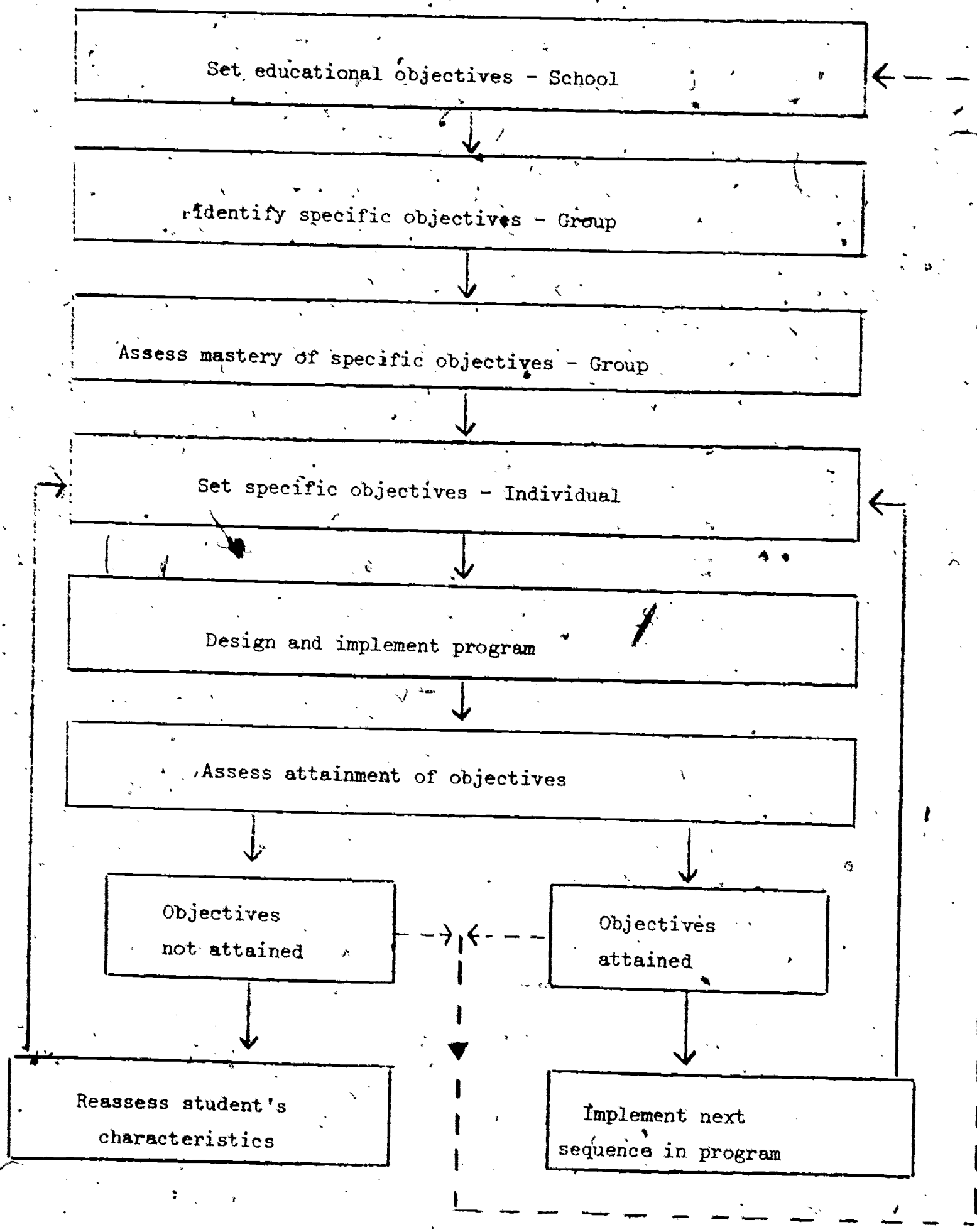

Figure 2. Instructional programming model in IGE

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