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»Learning in dual structures. Contributions of vocational education practice to the development of a new learning theory«

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The theory of learning is crucial to an infinite number of theoretical and practical issues. It plays a central role for instance in psychological therapy, in commercial marketing, and, of course, in teaching. There is, however, a great number of theories that are to contribute to its understanding. Generally speaking, these different theories lead to either causal explanations as do the behavioural, actional and cybernetic approaches. These explain learning efforts by some sort of discrepancy, be it internal or environmental. Other theories lead to an understanding of goal-free, contextual learning. Those are over and above cognitivist approaches in which learning is enhanced by the need for meaningful internal structures or interpretable external perceptions.

Despite this great variety in theoretical concepts, none of them is able to cover the whole width of possible learning situations. All of them have to be taken into consideration. The worst which might be done in this situation is to favour the one and to condemn the other theory without sound reasoning, as for a long time it has happened to the behaviourist learning theories. Nonetheless a systematic learning theory is missing. An essential step towards a systematic theory of learning is induced by the latest theory in vocational education. In order to illuminate its conception, we first will sketch out this theory in its central positions and develop from it a hypothesis on the integration of different learning theories. Then two theories of learning will be opposed to one another in a second step. Third, the systematic nexus between the concurrent theories will be lined out. In a last step, we will ask for empirical evidence and further research to be carried out.

1 From vocational education practice to a new and comprehensive theory of learning

The practice of vocational education differs remarkably throughout the European countries. We know on the one hand systems which are entirely based on learning professional skills and acquiring professional knowledge at school. We know on the other hand systems which are completely based on in-company-training. The German system of vocational education, however, combines the two opposed didactical approaches in a so called »dual system« of vocational education. Whereas in Germany there are serious internal debates on its efficiency, its success is widely recognised in other countries.

Given the interpretation from outside the country be the correct one, the question which arises then from this stunning observation is, how this success of the »dual system« could be explained. The idea that simply both ways of acquiring professional competence might be necessary does not seem substantial enough to give appropriate explanation: Principally, there is no hint on the nature of the interconnection between the two learning contexts, the firm and the school. Even if it did exist, it should in this case be possible to enable some sort of transformation from the one form of vocational learning to the other. There had to be a way of building a didactically adequate link between acquisition of theory at school and work experience in the company. This is clearly not the case, for it meant that learning at school and learning in an enterprise would produce indistinguishable results.

As Hans-Carl JONGEBLOED has pointed out (*cf.* 1998 a), a key to this issue is given by the Copenhagen explanation of »complementarity« by Nobel-prize winner Niels BOHR. He was concerned with the explanation of the phenomenon of »light« which can be proved to be a particle just as much as it can be proved to be a wave in other experiments. This was to the physicists a very troublesome observation for it is a violation of the fundamental postulate of *tertium non datur* in Aristotelian logic. In physics, »particle« and »wave« are contradictory. This made physicists rather helpless. BOHR came up to declare »particle« and »wave« complementary explanations to the phenomenon of »light«. This means »particle« and »wave« cannot be considered at the same time, for they are contradictory. However, the researcher has to be aware that only both give a full description of the phenomenon taken into consideration. A full understanding of »light« is thus given then and only then when a physicist keeps both contradictory approaches on his mind even though he is always bound to concentrate his research on one of them at a time.

Morphologically, the relationship between »theory« and »practice« is the same. They are just as much two contradictory approaches to vocational learning: for sure they cannot be taught at the same time. In most cases they can neither be taught in the same place. Only if both ways of learning and teaching come to their right though, substantial professional competence can be the result of the intended didactical process. This explains the great success of the »dual system« in vocational education, which was implemented about a century ago on the foundations of craftsmens' apprenticeship which is going back to the medieval age all over central Europe.

In monal systems, that is, systems that only allow learning either at school or in a firm, there are a number of different obstacles which are closely connected to the way of teaching and learning. In a monal schooling system the acquisition of holistic knowledge and behaviour – e.g. the role of social relations in professional life – has to be experienced by the learner after the end of school. This has caused serious insertion problems in labour markets of the respective countries. In a monal system of in-company-training, very often the appropriate guideline theory, indispensable to autonomous professional activity, is substituted by everyday's knowledge.

This observation gives way to a new theory of »bildung«, a technical term from German philosophy which is – although idiomatic – regularly translated into English by the word »education«. Contrarily to »education«, »bildung« emphasises the learning and the development of the individual rather than the relation between the educator and the educated. The »complementarity theory« of bildung acknowledges the recognised goals of »individual autonomy« or »emancipation« within the field of education and puts it on a new basis (*cf.* JONGEBLOED (ed.) 1998). This means that the goal of vocational bildung is not limited to a specific situation, but it is bound give the individual the flexibility to fulfil competently a broader number of coherent tasks. This means, too, that quite along the lines of a word of Herbert SPENCER („The great aim of education is not knowledge but action."), the goal of bildung must lie in the competence for vocational action, not in the ability to recapitulate professional knowledge, whatever detailed it might be.

The complementarity theory of bildung might also contribute to a new framework of learning theory. It will do so by delivering a new hypothesis. Successful learning cannot solely be explained by a regulation theory of action as for instance put forward by MILLER, GALANTER & PRIBRAM 1960. Nevertheless, it can neither be fully explained by a structural or procedural approach on cognition as for example argued in AUSUBEL 1968. However, »cognition« and »action« become the complementary categories of a new learning theory: Contradictory to one another, they are necessary to explain substantial learning which does neither lead to inert knowledge nor to unconscious or unreflected behaviour.

In simple terms, this hypothesis can be formulated as follows: *»Cognition« and »action« are excluding one another at the same time on the same topic. Both are transcendental to personal sovereignty.* – This hypothesis is to be elaborated in the following.

2 Two types of 'classical' theories of learning

As has been pointed out, there is a large number of different learning theories. They can be subdivided into two groups, those of a causal or procedural character and those of an undirected or structural type. It will be exemplified by the above mentioned approaches of MILLER, GALANTER & PRIBRAM (1960) for the first, by AUSUBEL (1968) for the second group of theories.

2.1 Procedural theories: MILLER, GALANTER & PRIBRAM

This first group of learning theories comprises the behavioural, actional and cybernetic approaches. Whereas the causal structure of the behaviourist approaches is a linear one – the response is following a stimulus in the reflexologic conception (PAVLOV 1923), behaviour is following sanction of antecedent behaviour in the theories both of THORNDIKE (1898) and SKINNER (1938). The probabilistic causal nexus of the last mentioned is already very near to the causal structure in the cybernetic approach, which is a circular one and which forms the morphological structure of learning theories based on action regulation as we know them by MILLER et al., not to forget by PIAGET (1975). In any case, there is some change in the environment which enhances or triggers behaviour, and a change in the environmental conditions gives the explanation for learning.

Be it internal or environmental, in all of these theories there is something triggering the learning effort. Generally speaking, this is some sort of discrepancy: In may be a physical stimulus (PAVLOV), a wish for reward or a desire of avoiding discomfort (SKINNER), a model (BANDURA 1977) or an image (MILLER at al.) of an expected state after action, it can as well be found in a strive to overcome "disequilibria" (or mismatches) between patterns of action and environmental conditions (PIAGET). In any case the learning is directed towards a procedural phenomenon like »action« or like »behaviour«; in any case the learning does always

refer to an earlier version of this procedural phenomenon. Schemes are derived from schemes (PIAGET), plans are generated from plans (MILLER et al.), behaviour or reflex is differentiated or generalised on interconnections between other stimuli and responses or rewards.

In the first place, the theory of George A. MILLER, Eugene GALANTER and Karl H. PRIBRAM has not been designed for an explanation of learning processes but for that of action regulation: Their problem is "to describe how actions are controlled by an organism's internal representation of its universe." (1960, p. 12). Though all of the authors involved were committed to behavioural theory before, they broke up with its strictly empirical foundations laid by WATSON (1913; *cf.* MILLER et al. 1960, p. 211). They distinguish action to behaviour by its purposefulness. Action means oriented behaviour which is organised or regulated by plans. Both purpose and plan of action are hidden or internal phenomena which can hardly ever be observed.

MILLER, GALANTER & PRIBRAM come to the conclusion that any kind of action is oriented by "images" and is regulated by "plans". An "image" in this sense is a sort of "knowledge of the world" (p. 1), it is an "internal representation" (p. 7). A "plan" is required to exploit the information contained in the image for action, it guides the behaviour and structures the sequence of action (*cf.* p. 2, p. 16). Plans are organised in a hierarchical way, that is, a plan »X« can be the "metaplan" (p. 178) to plans »A« and »B« which may consist themselves out of a number of plans »a«, »b«, and »c«, »d«, »e« (*cf.* p. 13). In their view, a plan is some type of information processing in analogy to a computer routine (*cf.* p. 16).

The elementary unit of analysis is a feedback cycle (*cf.* ch. 2). It is called "TOTE unit" (p. 26), an acronym formed by the sequence of "Test-Operate-Test-Exit" (p. 27). The initiation of action is bound to some sort of "incongruity" (p. 26). After every operative stem, intended and actual state are compared again, if congruity is given, there will not be any further action, in the other case the operation will be repeated. "Planning can be thought of as constructing a list of tests to perform. When we have a clear Image of a desired outcome, we can use it to provide the conditions for which we must test, and those tests, when arranged in sequence, provide a crude strategy of a possible Plan." (p. 38).

Plans are communicable (p. 119). This means on the one hand that they can be learnt from others, or they can be delegated to others; the communication of plans, on the other hand, implies that people feel free to describe their plans to a third (p. 120). Plans can comprise a marginal time span, and just as well a very long period. It may take a long time to realise its goals (p. 119) or it may happen that a certain time has passed by after a halt (*cf.* the so-called ZEIGARNIK-effect, cited on p. 68). Plans can be elaborated a long time in advance or be created almost simultaneously, the planning itself can be done quickly or at low speed. Plans can be meticulously worked out in detail or not (p. 119). They can be flexible or time-invariant, they can be co-ordinated with other plans, and with the plans of other people. The perseverance of the execution of plans may be influenced not only by the fulfilment of the goals, but also by time-limits, social (dis-)agreement, or other sorts of obstacles (p. 120).

Learning, in terms of remembering, problem-solving and generating new plans is, again, in itself a question of appropriate plans (p. 125-138, p. 159-194). Plans for remembering are of a mnemotechnical type, that is, planned remembering happens by the use of already established associations or familiar situations. Plans for searching and solving are called heuristic plans that will operate some sort of searching activity until a solution is found. The generation of new plans will generally happen by derivation from older plans (here we find a most striking parallel to the theory of PIAGET).

Although it is the declared interest of the book „Plans and the Structure of Behavior" to fill up the „theoretical vacuum between cognition and action" (1960, p. 11), it is unfortunately easy

to prove that in this respect MILLER et al. miss their point: They underline that “a plan can be learned and so would be part of the Image” and “Knowledge must be incorporated into a Plan, ... Thus, Images can form part of a Plan.” (both citations p. 18). If knowledge must be incorporated, images must necessarily form part of a plan. It can be agreed upon that (disregarded the lack of precision of the second) both sentences are true – it will only mean that a ‘plan is part of an image’ and an ‘image is part of a plan’. Either there is a common third (like a subset), which should have been named by the authors, and it should have been most thoroughly considered in sake of filling the ‘vacuum’ as intended. Or – as we would say – the relationship between »plan« and »image« is a complementary one. Then both sentences are ‘true’, it is only that this cannot be simultaneously on the very same subject.

It could be said that MILLER, GALANTER and PRIBRAM have contributed much to the understanding of two different plans – one of action and one of planning. Nevertheless these plans are morphologically just as incompatible as the plans for making accurate measurements of the impulse and the location of an atomic particle simultaneously. Interestingly enough, this reference is given as an example of incompatibility of plans by the authors themselves (*cf.* p. 97).

2.2 Structural theories: AUSUBEL

The second group of learning theories is interested in an understanding of building, enlargement, retention and reorganisation of the structures of the content which is the subject of learning. This type of learning theory does not explain the use of knowledge, its purposefulness or causality. It is restricted to what the other theories have left out: the internal conditions of learning. They are so-called cognitivist approaches in which learning is enhanced by the need for meaningful internal structures or interpretable external perceptions. They do not consider the possible reasons for learning but its contents and conditions. Following the conception of David P. AUSUBEL 1968, knowledge can also happen to be an end in itself (*cf.* p. 31). His theory is directed in the first place to an explanation of school learning, this has to be conceded. Nevertheless, this cognitive learning theory gains its power by its didactical application.

The central point of AUSUBEL’s argumentation is that there are different types of learning, which require – contrarily to other researchers’ standpoints – different explanatory models (p. 20). These different types of learning can be differentiated along two categorical dimensions – “one distinction between reception and discovery learning and another between rote and meaningful learning.” (p. 21). The first dimension is not exclusively, but most closely connected to teaching: It deals with the form of presentation of content to the learner. If the whole content is presented in a final form, then the learning shall be called “reception learning”. If the learning is initiated by some sort of media arrangement, and the “principal content of what is to be learned is not given but must be discovered by the learner” it is named “discovery learning” (all citations p. 22).

It is quite obvious that discovery learning does require a lot more time at school than reception learning (p. 23). This could only be justified by greater success on the output side of the calculus – which is, according to AUSUBEL, a question of meaningful integration of content (*cf.* also p. 58-62), not primarily of the way it has been presented to the learner. Meaningful learning, that is, the acquisition of content which can be integrated into the given cognitive structure of the student. It is opposed to rote or verbatim learning that does not lead to a stable cognitive structure and information retrieval. It is lined out that the attribution of meaning can happen in both ways of teaching, either the way of reception learning or the way of discovery learning. This disconnection can be shown by the example of laboratory learning, when the students follow cookbook algorithms without real understanding, and do not integrate their

'findings' into their cognitive structures (*cf.* p. 25, p. 85-87). Irrespective of how an active or motivated student obtains knowledge about something, he will reflect, reconsider and integrate new material into his cognitive structure (*cf.* p. 88).

Given this economical interpretation of the two dimensions, the focus must be: How can meaningful learning be realised? First of all, the content must be meaningful in itself, so it has to be logically ordered and must by its material quality be "relatable to his [the student's, V.B.] structure of knowledge on a nonarbitrary and nonverbatim basis." (p. 38). For instance, if a list of adjectives is to be memorised, it is clear that every adjective is meaningful, though this cannot automatically be attributed to the list as a whole (*cf.* p. 46). It requires, too, that the learners manifest a meaningful learning set, which means that their cognitive structure allows meaningful integration of the material (*cf. ibid.*). This last aspect is usually characterised by experienced teachers in Germany by the didactical maxim of "meeting the pupil at where he is". It points at cognitive content or prior educational background, at (developmental) readiness or age, IQ, occupational, social and cultural factors (*cf.* p. 40; ch. 5).

AUSUBEL does not fail to mention that the resulting cognitive structure is an ideosyncratic phenomenon (*cf.* p. 45). Despite this fact, it can be said that "cognitive structure itself tends to be hierarchically organized with respect to level of abstraction, generality, and inclusiveness" (p. 52). This occasions anchorage, which will enhance retention of the newly learnt material: The new idea will be stored in "linked relationship" to other ideas that are most relevant to it. This anchoring will make the process of retrieval easier (p. 92). In this context, AUSUBEL makes a difference between derivative subsumption (e.g. like with an specific example of an established concept in cognitive structure) and correlative subsumption (in this case, the new material is an extension, elaboration, modification, or qualification of previously learned propositions"; p. 100).

All in all, the cognitive structure is relevant to new learning processes and thus learning transfer regularly occurs (*cf.* ch. 4, in particular p. 128). Given this, it becomes clear that a well-defined, stable and well-organised cognitive structure is crucial to learning efficiency. The didactical consequence, intending to enhance proactive facilitation or to reduce proactive inhibition, must consist of a presentation of relevant and inclusive introductory material in advance, which is stable and clear enough to organise the learning process. The organiser is supposed to bridge the gap between the given cognitive structure and the learning set required for integration of new material (*cf.* p. 148). The sequential arrangement of learning content proves to be of utmost importance (*cf.* p. 159).

As a matter of fact, AUSUBEL rejects more than once the computer illustration for human cognition (e.g. p. 175) and tries, if at all, to follow the guidelines of the physiology of a brain (*cf.* p. 153). Yet he is not aiming at a learning theory that could 'leave the schoolyard'. In fact, as impressive his argumentation is, it undisputedly remains open, how real-world-activities could be integrated or grounded on this theory of learning. This again makes clear that AUSUBEL on the one side, and MILLER, GALANTER and PRIBRAM with their computer-like explanation of action regulation on the other side remain in two contingent, if not antagonistic frames of reference.

3 A system of learning theories – complementary learning

At first glance, it seems to be surprising that the two types of learning theories seem to be focussed on two distinctive traits of learning, the first being procedural, the second structural. Since the old dispute between PARMENIDES and HERAKLITUS we know that there is no way in referring one aspect to the other – nonetheless we all know that the change in structures implies some sort of dynamics, some kind of procedure in between. Yet evidently a procedure

needs to have a beginning and an end, thus it in fact starts with a structural state and finishes with another. This unveils again a morphological structure of complementarity: We cannot make an enquiry on the process and on the structure of learning at the same time. So, after all, it is no more surprising that we find two distinctive and clearly opposed groups of learning theories. For a comprehensive understanding of the phenomenon of »learning«, however, both have to be acknowledged.

The more, education or, more concretely, teaching which is aimed at personal sovereignty must accept that only one aspect can be taken into consideration at once. Nevertheless in the end of the education process, both conceptions must have been given their tribute. Thus, in order to develop an integrative and systematic learning theory, the underlying concept of »complementarity« must be respected and it is worth giving this integrative approach its name.

To give some more evidence, we will give a short outline of the shortcomings of the two concurrent approaches. The theory of MILLER et al. can explain the procedure of action by the concept of »plan«, it even can explain its variation by learning. It is not in the position to explain how this variation occurs: a plan remains something hidden, something abstract. The authors concede themselves that although a plan of action can occasionally be verbalised, it never will make sure that action itself takes place in an appropriate way (1960, pp. 82-84). If at all, it controls the action by comparing its intentions with its results. No plan, however, does guarantee the success of action under any circumstances. Put it this way, it becomes obvious that successful action is bound to experience. Insight or verbalised instruction might help to reach the goal – it is not part of the action itself. Throughout the whole book there is not the least explanation how action is learned, except for the modification of anterior plans (p. 177). Certainly, they mention several times that a plan is “stored”. They point out that planning is controlled by plans of a superior level, so-called “metaplans”. But the central question, how the storage is happening, how the metaplans of the highest level are created remains rather dull.

They also write: “Children acquire their store of heuristic methods by listening to verbal suggestions and then trying to execute them ...” (1960, p. 184). They ‘try it out’ – and that’s it: Successful action is undisputably a question of learning by experience. The theory of MILLER, GALANTER & PRIBRAM explains action and action learning. It shows, too, that the improvement of action happens to be a question of experience, and that the improvement of plans is a question of insight. Whereas insight can be verbalised and thus be transferred from one person to another by communication, experience must be acquired individually. Experience leads to so-called “tacit knowing” as conceptualised by Michael POLANYI (for example POLANYI 1962, 1966). Tacit knowing means that it is bound to one individual and extremely difficult or impossible to be verbalised for communicating it to a third party.

A different shortcoming is to be found in the theory of AUSUBEL. His concern was to integrate new knowledge into a given cognitive structure. This was, what he has called »meaningful learning«. Though verbalisation is not a condition of meaningful learning, it will frequently be based on verbalised contents. The fact of meaningfulness, however, does not ensure the fertility of the new cognitive structures. The reach of cognition is strictly limited to the individual’s brain. It only becomes relevant to the rest of the world by this very individual’s action. Otherwise, if it does not lead to any action at all, the process of learning will have produced to something which has been named “inert knowledge” by Alfred N. WHITEHEAD (1929). He had criticised this learning result as inefficient and even harmful. Since WHITEHEAD’s verdict, many have come to the shortcut conclusion that school must not teach any facts at all, or even that school was not of any use. Both is undoubtedly false, although this criticism of school learning goes back two thousand years to SENECA, who postulated that

we should learn for life, not for school (*cf.* 106th letter to Lucille). It is inevitable that, in order to fulfil this postulate, some kind of learning transfer is needed. This however is the missing point in a monal schooling system as well as it is in cognitive learning theory.

The consequence of these observations must be that the teaching of experience-oriented and that of insight-oriented topics do not only require a complementary system of different theoretical approaches, they necessitate distinguishable didactical conceptions. For all of the historical reasons of being a political compromise between the stakeholders in German society, the German »dual system« does respect the need for different types of learning by setting up two fundamentally different learning environments: There is systematic learning at school and experimental learning at work. As both focus on the same frame of contents, which is set up by the apprentices' profession, it enables the apprentice to acting professionally in a competent way, if the structural knowledge and the procedural experience get connected in his or her brain under the conditions of any singular situation. This ability to professional competence will then be given even in an unfamiliar situation which calls for an innovative sort of action.

The ideal didactical approach at vocational school must be oriented towards the learning of a maximum of systematic knowledge, be it facts, be it plans. It must be, according to the outcomes of the learning theory lined out by AUSUBEL, coherent in itself, and the coherence could be made overt, too. In the »dual system« it is current practice to leave exactly this connection up to the apprentice. It is the apprentice's problem to re-organise autonomously the cognitive structure by the method of discovery learning. But, in order to simplify the individuals' task of transferring it into practice, it might be useful to give it some additional meaning by making references to certain professional activities: 'These facts are required for action »X«', 'this plan is basic to activity »Y«', 'this procedural knowledge might be helpful in situation »Z1«, »Z2« or »Z3«'. Making sure that the students will be in a position to acknowledge the worth of the facts and plans learnt at school, would explicitly become the teachers' task.

This could be interpreted in the sense of delivering the advance organiser for transfer from the »learning field« to the »functional field«. Thus it could be given some support to that the knowledge be not merely compiled (and thus in danger of becoming inert knowledge), but that it also gets integrated into an individually holistic professional competence. But, what remains most important is that school does what it is expected to do: "It is ... a commonplace that the details of a given discipline are learned as rapidly as they can be fitted into a contextual framework consisting of a stable and appropriate body of general concepts and principles." (AUSUBEL 1968, p. 128) Only ignorant didactics will postulate action-oriented teaching at school, which neither does incorporate structures of general validity nor stable relations for action is inevitably bound to the brief moment elapsed.

Contrarily to these consequences for the learning at school, the didactical approach at in-company-training must be focussed on the maximising of experience. This can be obtained by repetitive action on the one side of the scale or discovery learning in a well-defined stetting on the other. Professional competence will be better developed, if the instructor takes care not only to control that the required action is undergone faithfully and thoroughly and is leading to high-quality products or services, but also to ensure that the apprentices are encouraged to theoretical reflection of their doing. This will be a substantial contribution to keep explicit as much individual knowing as possible and to make it transferable to newly defined situations respectively make it communicable to others.

4 Empirical evidence and further research

Certainly, the first evidence is given by the »dual system« of vocational education. Its particular success is based on the two opposed structures of learning environments in the firm and at vocational school. Systematic learning, directed towards the formation of cognitive structures is mostly considered to be the task of the school. Regulative learning, aimed at the acquisition of procedural abilities undoubtedly is best learned in the holistic context of real world. The instant in which the results of these two learning processes are brought together by the individual apprentice is the moment of reaching the educational goal.

Although the theory of complementary learning is just about to emerge, there is already further empirical evidence to its validity. For the purpose of investigating the existence and possibility of learning transfer a number of experiments have been carried out by JUDD in 1908 and, later on the basis of the results of this study by HENDRICKSON & SCHROEDER (1941) and in particular by OVERING & TRAVERS (1966). Their fundamental observation was that the success of action was far better, when it was not only left to accidental attempts but accompanied by the learning of the underlying principles of the tested action. On the other hand it is quite evident, though not the impetus of all these studies that mere memorisation of the required facts would not necessarily mean anything to the quality of later action. One could say that also AUSUBEL recurred on those theories of learning transfer (*cf.* 1968, p. 138), yet he was referring to the problem of learning transfer within the field of (school) learning, not between school and reality. In this case it might be supposed that he did not carry the interpretation to its extremes.

However encouraging and convincing the already existing evidence may be, at the rise of a new paradigm of learning it is quite clear that it is necessary to carry out substantial experimental and field research in order to find further evidence to the supposed efficiency of complementary learning. If it should be possible to find sound empirical evidence, then this theory would be in a position to enlighten many didactical problems and a number of questions which are put forward by the organisation of learning both at school and within companies.

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