A Learner-centred Input–Output Model

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Abstract

Meaningful learning can be maximised by knowing what are the contributing structures (inputs) the learners carries with him/her into the classroom and using which he/she is going to construct new structures (output). In this research paper, a four-dimensional input has been presented and key information for the measurement of the inputs in the classroom situation has been discussed. The output has been delineated in the conceptual change model of the constructivist approach.

Introduction

During the second half of the twentieth century, the Teaching-Learning Process (TLP) as practiced inside the classroom has evolved through three broad paradigms, ensconced within the philosophy of Freedom of Necessity. The Necessity is defined by the demands of

- Social and cultural changes,
- The explorative investigations, particularly in science, and
- The new evidences about how a learner learns.

On the other hand, the individual learner has the Freedom to choose the context of learning. As a result of this,

- The focus of TLP has gone through continuous change,
- The domain of TLP operation has expanded beyond the walls of the classroom,
- The structures of TLP have been redesigned to meet the ever evolving situations,
- The form of TLP has been redefined,
- The operational modalities of TLP have been modified beyond recognition, and
- Evaluative procedures have been made more functional to meet grass-roots level realities.

In this process of evolution, the approaches to TLP have changed from the transmissionist one to the cognitive one, and now to the constructivist one. However, in this process of evolutionary

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changes (Kuhn, 1970) the two important human inputs, which obviously have remained unchanged, are the teacher and the learner.

The teacher brings with him/her, his/her

- Personality (which could be pleasant, smiling, caring, arrogant, angry, terse, authoritative, etc.),
- Content knowledge (which could be say, in the case of science teachers, textbook science, scientists' science, indigenous science, his/her personal construct – science, etc.),
- Pedagogy knowledge (which could have been acquired through professional training, years of experience, self-developed but operationally effective strategies, orientation programmes, etc.),
- Pedagogical content knowledge (Shulman, 1987) (which might have been developed through his/her innovation, socio-cultural context, linguistic expertise, infrastructural facilities available in the school etc.), and
- Creativity (generated and refined over years through self-modulated efforts, programmed orientations, etc.).

and perhaps a host of other factors into the classroom. These are inputs by a teacher in a classroom situation. He/she uses them in a way which he/she thinks is effective and expects certain learning outputs in the learner.

Similarly a learner, (independent of the teacher) brings with him/her a lot of inputs which he/she then uses in learning new concepts, events, examples, etc.

Thus an input-output model of learning must then necessarily build upon either a teacher-specific or a learner-specific or perhaps a composite-specific (where perhaps the teacher and the learner can be taken in unison) framework.

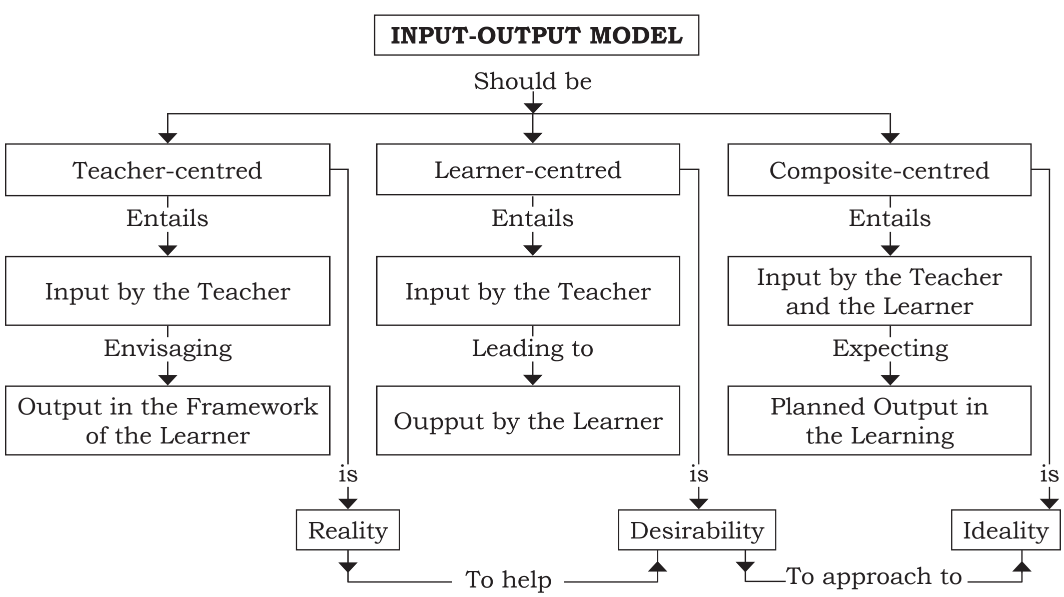

Figure 1

However, we are conscious that in this discussion we will not be considering such inputs as textbooks, infrastructure facilities, school specific co-curricular practices, contribution by the society in terms of Village Education Committee and other such organiations, use of electronic media, incentives in the form of scholarships, etc. because they are policy-prescribed inputs over which neither the teacher nor the learner has much of a say.

In 'Reality', the TLP as practiced even now in the classroom is mostly a teacher-centred input-output model. It entails inputs by the teacher. It envisages a prototype output in the learner, confined within the philosophy — 'What is relevant for examination is relevant for education'. However, in the context of learning in the constructivist framework, the 'Desirability' of TLP consists of input by the learner leading to output by the learner. One may call this the learner-centred input-output model. However, optimisation of TLP leading to maximization of meaningful learning cannot afford to consider the teacher and the learner in isolation. Thus in 'Ideality' the composite model for TLP involves input by both the teacher and the learner expecting a planned construction by the learner. This means the 'Reality' should help the 'Desirability' to approach the 'Ideality'

In this research paper we shall confine ourselves to the crucial learner-centred input-output model. We call this crucial because through conclusive field study-based evidences constructivism advocates that

- the learner constructs his/her knowledge,
- no learner enters a class devoid of personal constructs (Alternative conceptions), and
- knowledge is constructed through a process of conceptual change (Posner et al, 1982; Hewson and Thornley, 1989)

Thus to maximise meaningful learning it is essential to know what are the contributing structures (inputs) the learner carries with him/her into the classroom and using which he/she is going to construct new structures (output).

Inputs

The inputs by the learner have four discernible dimensions, which are

- Intrinsic inputs
- Constructed input
- Cognitive preference input
- Concept-based input

Dimension 1: Intrinsic inputs

These inputs depend on the age, genetic design, biological growth as well as socio-cultural background of the learner. These are further classified into two categories (a) Mental developmental level of the learner and, (b) Creativity of the learner.

(a) Mental developmental level (MDL) of the learner: When a learner enters a class, obviously his/her mental developmental level or, mental readiness determines the concepts he/she can construct and internalise. If there is a mismatch between the MDL of the learner and the cognitive demand level of the concept, then even the best efforts by a teacher to facilitate the construction by the learner will result in a constructed concept which will be most likely not the desirable one.

Hence, this puts a premium on educational administrators, curriculum framers, textbook authors and classroom teachers to at least ascertain the average MDL of a group of learners in a particular class before they are exposed to actual learning situations.

Several models are available in the literature to perform this task.

i) Piagetian Stage–dependent model

In this model, it is important to note the following points :

- Although the stages form a nominal scale, they can be functionally converted to an ordinal scale for use in a classroom situation.
- In this model the inbuilt lacunae are that the Piagetian clinical interview technique is individualistic in character and is time-consuming. These inhibit the technique to be transported, as such, into a classroom situation, involving large number of learners whose MDLs spread over quite a few Piagetian stages.

Inspite of this, the Piagetian model is still a fairly reliable reference point and hence there have been large number of efforts to take it into a classroom.

Longeot (1965) was the first to take Piaget into the classroom by overcoming the above limitations of Piaget's method Clinique. His was a text of combinatorial thinking, propositional logic and proportionality. He used scalogram technique to analyse the responses. But he did not give the date on inter-task correlations, nor, on the reliability of the task. It was purely a pencil-on-paper test and demanded reading visual recall and writing abilities. Bruner (1960) had earlier commented that such tests are likely to put the pupils in suspicion. Further the responses in such a test rarely reflect the MDL of the child, measured in terms of the ability to handle specific logical structures.

Raven (1973) developed a test of logical operations. It was again a pencil-on-paper test of classification, seriation, logical multiplication, compensation, proportional thinking, probability and corelational thinking operations. Thus, although as compared to Longeot's test, Raven broadened the range of logical structures to be tested by a tool, his test suffers from the limitations of a pencil-on-paper test.

Tisher and Dale (1975) went a step forward by introducing an apparatus which should be on view during the administration of their understanding in science test. But the apparatus was never used as an aid to supplement the actual administration of the test. Further it distinguished between only formal and concrete operations without any finer discrimination.

Rowell and Hoffman (1975) developed a group task to be given in a laboratory with each pupil using an apparatus. The disadvantages are that one needs a spacious laboratory and a large number of apparatus, which in any way does not relate to a realistic classroom situation. Further the responses of any child depended upon how he/she completes the experiment and hence demands on his/her experimental skill which does not necessarily reflect his/her MDL.

To do away with the requirement of a large number of apparatus Issacs (1976) used video-taped presentations. Apart from the fact that this demanded a high level of pictorial perception-to-comprehensional ability, the test also relied heavily on ticked answers, which involved high probability of guessing. Thus the conclusions arrived at from the responses are likely to be quite off the mark.

Shayer and Wharry (1973) developed Seven tasks in which the administrator presented the questions verbally while demonstrating the activities with a simple apparatus. However, they did not provide data on the reliability and validity of the tasks.

The CSMS (Concepts in Secondary Maths and Science) group at Chelsea College, London, in 1974, subjected all the Shayer-Wharry tasks through a thorough psychometric developmental process. The final versions of these tasks are called the Science Reasoning Tasks (SRT). These tasks have the following characteristics:

- Their reliabilities are well-established.
- Each task requires one very simple equipment for stepwise demonstration of different items.
- They do not impose any constraint on the responses in terms of adequate verbal ability as they demand short answers from the pupils.
- The provision of short answers also eliminates the effect of 'guessing' as is common in case of ticked answers.
- The internal consistencies of the tasks as measured (Johnson, 1977) by KR-20 coefficients have values around 0.85.
- The test-retest correlation is also as high as 0.8 (Johnson, 1977).
- Even the task-interview correlations are quite large (Shayer and Adey, 1981) indicating a direct correspondence with Piaget's method Clinique.
- At the end of each demonstration in the context of an item in the task, the pupil is asked to
  — guess what could happen; and
  — explain what actually happens.
  Responses to both these are likely to reflect the mental level of the child.
- Each task is a good discriminator over a range of Piagetian stages.
- They have a cross-cultural validity. In fact, the validity of tasks III and IV, under Indian conditions, have been established by Mohapatra and Mohapatra (1997)

Lawson (1977), without the knowledge of the already developed SRT designed a set of tasks independently. But they suffered from the defect that the test items were not classified as concrete, or, formal before trial. The stage assigned to each score range was determined by past-hoc inspection of contingency table.

ii) Pascual-Leone's M-Power Model

The proponents of the neo-Piagetian approaches to diagnose and map MDL of pupils advocate that Piaget's theory suffers (Pinard and Laurendeau, 1969) from several drawbacks like horizontal and vertical decalages and low correlation between tasks which are supposed to be passed at about the same age and MDL, such as, conservation, classification and seriation.

Pascual-Leone retained the Piagetian notions of scheme, assimilation, differentiation, accommodation and structural invariants, but introduced the concept of M-Power (Pascual – Leone, 1977, 1987). This facilitated the introduction of several hyperfine structures into the stage-dependent model of Piaget. He argued that the instruction does not have to be geared to some general logical structure, but to the specific pre-requisite structures of relevance to the domain in question together with the M-Power of the learner.

He introduced a new rule for stage transition by stating that the children progress from non-solution to solution of a developmental task when their M-Power increases to the point at which it can activate all the task-relevant schematic boosting, namely, scheme's own cues, field effects and logical, or structurally-related cues. A reliable and valid tool to measure the M-Power of the child has been developed by Pascual-Leone. Interesting and important case studies involving assessment of M-Power of pupils in a classroom situation can be obtained from Niaz (1988, 1991). One may use this M-Power framework to assess the MDL of the learner. However, in this formalism, to ascertain the M-demand of any concept, no general taxonomy is available in the literature, as is the case with SRTs (Shayer and Adey, 1981)

iii) Processing Space Model

Case (1985, and references therein) in an information processing framework, propounded that the completion of an item/activity by a learner should not be looked upon in totality because the process of completion goes through several steps, each demanding a different cognitive ability. Thus the completion of each step should be analysed separately. To operationalise this idea, he advanced the concept of Executive Processing Load (EPL). EPL is the number of schemes a learner must activate in order to complete one particular step in an executive sequence. The EPL for different steps will be different. He called the maximum instantaneous value of EPL as Maximum Processing Load (MPL).

In this model he introduced three variables, Total Processing Space (TPS), Operating Space (OS) and Short-Term Storage Space (STSS), which are related by the following equation:

TPS= OS + STSS

Thus a measurement of TPS and OS of the learner will also give an assessment of the learner's effective MDL.

iv) Vygotsky's Zone of Proximal Development Model

Vygotsky's (1962) analysis of the relationship between learning and development is the basis for his concept of the Zone of Proximal Development (ZPD). Vygotsky writes (1978) –"What the children can do with the assistance of others might be in some sense more indicative of their MDL than what they do alone". The abilities which help the child to accomplish this are mature as they must have been internalised by the child for quite sometime. These in fact reflect the Actual Developmental Level (ADL). There could be, of course, the abilities which the child cannot exercise at all, even with extensive assistance. These abilities may mature later. But there could be perhaps quite a few abilities which the child can demonstrate with assistance. These abilities could be considered as existing in the process of maturing. They are latent and need little props. These maturing abilities then provide excellent predictive information on how the child will/can perform independently in the near future. Thus, assessment of the soon-to-be-mature mental abilities provides a perspective measure of the projected performance ability of the child and reflects the potential developmental level called by Vygotsky, the Zone of Proximal Development (ZPD). Vygotsky asserts that an assessment of ZPD of a child will also indicate the functional mental developmental level. It is stated in brief by the following equation:

MDL = ADL + ZPD.

In view of the above research findings, we recommend the following:

- Taking a broad-based sample of learners one should have a statistically clear picture of the MDL of the pupils in a class before even the curriculum is framed, textbooks are drafted, and the actual classroom teaching takes place, because MDL is the most important intrinsic input by the learner.
- An analysis of the cognitive demands of each concept to be taught in any class be undertaken simultaneously.

(b) Creativity of the learner: The learner also brings with him/her his/her creative abilities, which can be measured in terms of the classical model (Torrence, 1965, 1968), involving four parameters, namely fluency, flexibility, originality, and elaboration. Many culture-specific tools (viz. Sudhir and Varpari, 1991) are available in the literature for ready use. One may note that these four parameters are continuous variables and as contrasted to this model. The Oregon University

Group, U.S.A. has now proposed the quantum creativity model. One must not lose sight of the fact that creativity also plays a major role for the construction of knowledge by the learner.

Dimension 2: Constructed input

It is now known that the learner constructs knowledge in a continuous ontogenic (Glasersfeld 1992) process. However, as had already been clearly stated by Ausubel (1968), the degree and quality of construction is decided by the Alternative Conceptions (ALCONS) of the learner. Since 1980, there have been focussed efforts to:

- diagnose and map learner's ALCONs;
- refine and innovate new techniques to carry out this diagnosis;
- study ALCONs cross-cultural vitiations, if any;
- identify genesis of ALCONs, common to a group of learners;
- study the characteristic of ALCONs;
- locate implications of ALCONs for TLP; and
- develop and try out teaching models incorporating learner's ALCONs.

Comprehensive reviews and overviews can be obtained from the books by Fensham et al. (1994), Steffe and Gale (1995), Glynn and Duit (1995) and papers by West (1982) Driver and Erickson (1983), Gilbert and Watts (1983), Hashweh (1986) and Mohapatra (1989, 1997). In fact studies on ALCONs were pursued so extensively and intensively that Gilbert and Swift (1985) called these endeavours as 'The Alternative Conception Movement'. To maximise the degree of meaningful construction by the learner it is imperative that the teacher should be equipped with knowledge, techniques, and strategies so as to be able not only to diagnose learner's ALCONs but also to suitably use them through cognitive negotiation in the TLP for an optimal and fruitful output.

Dimension 3: Cognitive Preference Input

Cognitive preference is a learner's stable mode of perceptual organisation of the external environment and the concepts taught to him/her (Tamir, 1985). In fact in the process of learning a concept through construction, cognitive preference of a learner is the self-induced reply to such self-asked question as — 'Why shall I learn this concept?' The answer to this question is obviously an input by the learner and becomes the guiding motive force in the process for further learning. Four cognitive preference modes have been indentified. They are

- Recall — It involves acceptance of information for its own sake without consideration of its implications, or applications. A preference for "Recall" indicates an interest in learning a name, a number, a definition, a formula, an observation, a fact or even a table.
- Principle — A preference for 'Principle' indicates an interest in identifying relationship between variables, or a rule that can be applied to a class of objects, phenomena or, an interest in explaining a phenomenon leading to

a representation of fundamental principles, or relationships.

- Questioning — A preference for 'Questioning' indicates an interest in critically analysing and commenting on information for completeness, general validity, or limitations, or in generating suggestions and hypotheses for further research.
- Application — A preference for 'Application' indicates an interest in using scientific information to solve problems in commerce, industry, farming, or in other real, life situations.

Cognitive preference ultimately controls the quality of meaningful learning by the learner. Although preference for 'Principle' is perhaps cognitively the best at the intake point where, very few learners have this cognitive preference. However, experimental results show that by suitable intervention techniques (Okebukola and Jedge, 1988) learners originally having preference for 'Recall' can be made to gradually adopt the cognitive preference mode of 'Principle'. But for this the teacher should have a tool (Tamir, 1985) to ascertain the initial cognitive preference of the learners. We note in passing that the mode of cognitive preference adopted by a learner is, many a time, specific to the concept domain and context.

Dimension 4: Concept-based input

Based on the two main observations of constructivism, namely

- Learning is a purposeful, intentional, ontogenic (Glasersfeld, 1992) sequence of construction of cognitive structures by the cognising subject, and
- Learning is pervasively influenced by ALCONs of the learners.

Posner et al. (1982) and Hewson (1981, 1982) developed the conceptual change model of learning as discussed in an earlier chapter. Activation of the process of conceptual change, when a learner encounters a new concept, requires an assessment of the concept by the learner. This assessment is subjective and purely personal to the learner and hence is a concept-specific input by the learner. Four conditions are associated with this autonomic process of assessment. They are as follows (Hewson and Thornley, 1989)

C1: The new concept has to be Intelligible

In the framework of the existing knowledge of the learner, i.e. the learner's ALCONs in the relevant concept domain, the new concept should convey meaning (not necessarily the correct meaning) to the learner. Without intelligibility a concept has no cognitive status (Hewson and Thornley, 1989) for the learner. Schollum and Osborne (1985) call this the criterion of relevance.

C2: The concept has to be Plausible

The new concept should not only be intelligible but also seem to be true and valid to the learner, i.e. it should make sense in the framework of the learner's ALCONs.

C3: The new concept has to be Fruitful

The new concept should be such that the learner should find it useful, or should be convinced that he can achieve something by using it. This achievement could be just logical consistency leading to mental satisfaction in the learner's framework, or could seem to have enough potential for fruitful use in future.

C4: The concept could be a source of Dissatisfaction to the learner.

This state may arise if (a) the learner finds that the new concept leads to conclusions which are in conflict with the existing ALCONs, or (b) they seem to be valid but are different from those arrived by other pupils using their respective ALCONs, or (c) the new concept does not seem to be plausible, or, fruitful to the learner, or (d) the connotation of the concept arrived at by the learner is in conflict with that advanced by the teacher (Dreyfus et al, 1990). Some of these have already been discussed under cognitive conflict but are repeated here to keep intact the framework developed by Posner et. al (1982) and Hewson (1982). The four learner-centred inputs are presented in Fig 2.

Output

Out of the four broad inputs by the learner, the intrinsic input decides the ability of the learner to assimilate a concept having specific cognitive demand, the constructed input decides not only the background but also the mosaic of the new construction, the cognitive preference controls the quality of construction and the concept-based input decides the final states of learning after the construction is complete. When a learner encounters a new concept, he/ she makes use of the learner specific four kinds of inputs and is likely to suitably assimilate and accommodate the new concept through needed deconstruction and reconstruction of

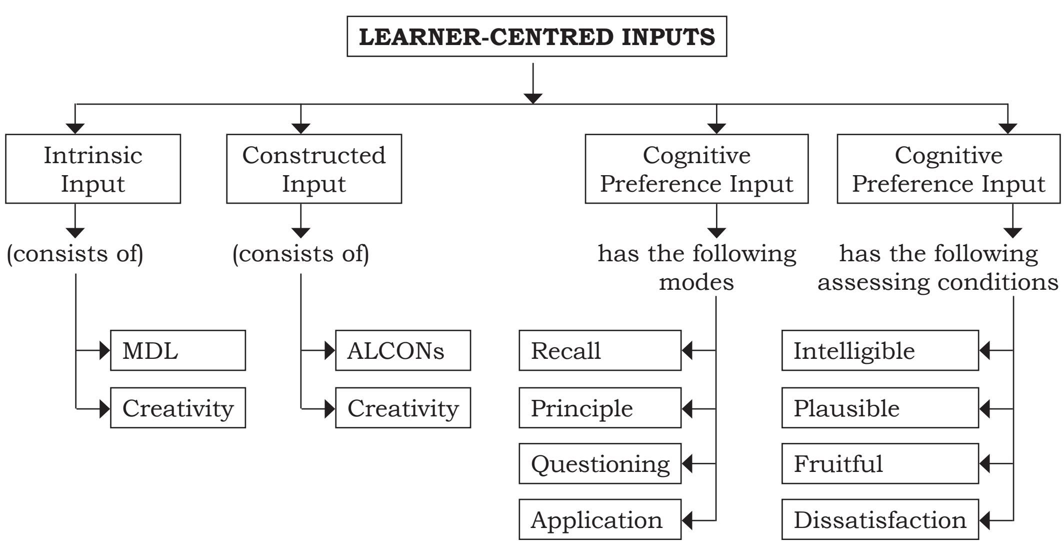

Figure 2

the epitaxy of his/her cognitive structures resulting in one of the various possible equilibrated (a la Piaget) states, which we call the output (OP) of learning. They could be one of the following (as discussed in the chapter on conceptual change (Mohapatra, 1997):

OP1: *Conceptual Rejection*: This will occur if either the new concept does not satisfy the condition C1, or the MDL of the learner is below the cognitive demand level of the concept. In such a situation the teacher's input (teacher-centred model) has to provide suitable props to ensure that C1 is satisfied, or that the learner attains some amount of cognitive acceleration (Adey, 1988)

OP2: *Conceptual Integration*: If condition C1 is satisfied but C2 is not satisfied, the learner may modify the structures of the existing ALCONs and accommodate the new concept (Hewson, 1981, Posner et al., 1982). It is a long-term process aiming at a stable final state.

OP3: Conceptual Extension: If the conditions C1 and C2 are satisfied and C3 is not satisfied, the learner may still absorb the new concept by adding new structures to the already existing ALCONs.

OP4: *Conceptual Capture*: If the conditions C1, C2, C3 are satisfied, then the new concept is incorporated straight away in the existing structures of the ALCONs (Hewson, 1981, Posner et. al., 1982). There are two possible sub-states under this as listed below.

OP5: *Conceptual Dichotomy*: If the conditions C1, C2 and C3 are satisfied but the concept is something different from the existing structures and cannot be incorporated into them by trial of various fitments, then the learner faces a problem. On one hand the learner is not prepared to abandon the old structures as he/she perhaps does not find anything wrong with them, and on the other hand he/she does not like to reject the new concept as it satisfies the three basic conditions. In such a case the learner is likely to retain the new concept as a new, independent ALCON, side by side with his/her old ALCONs (Mohapatra, 1989). Villani (1992) also hypothesises the co-presence of the old and the new knowledge.

OP6: *Conceptual Exchange*: This will happen when the conditions C1, C2 and C3 are satisfied and the new concept seems to have better, broader and finer utility value than some of the old ALCONs. Arriving at such a conclusion goes through a process of trial and error, hypothesis formation and testing in so far as organising his/her experiential world is concerned. In most of such cases a broad scale conceptual change takes place where some of the old ALCONs is/are replaced by the new one.

OP7: *Conceptual Indifference*: If C4 is strongly satisfied but C1, C2, C3 are also satisfied, the learner may neither accept nor reject the new concept. The learner may prefer in such a situation to keep his/her old ALCONs unchanged and remain indifferent to the new concept that is being taught. It may be noted that this is not a case of conceptual rejection.

These outputs are presented in Fig. 3. The seven possible outputs in the event of a learner encountering a new event, instance, or a concept form a taxonomy of outputs (Mohapatra, 1997). This taxonomy is more encompassing and richer than other such attempts, like those by Dykstra et al (1992).

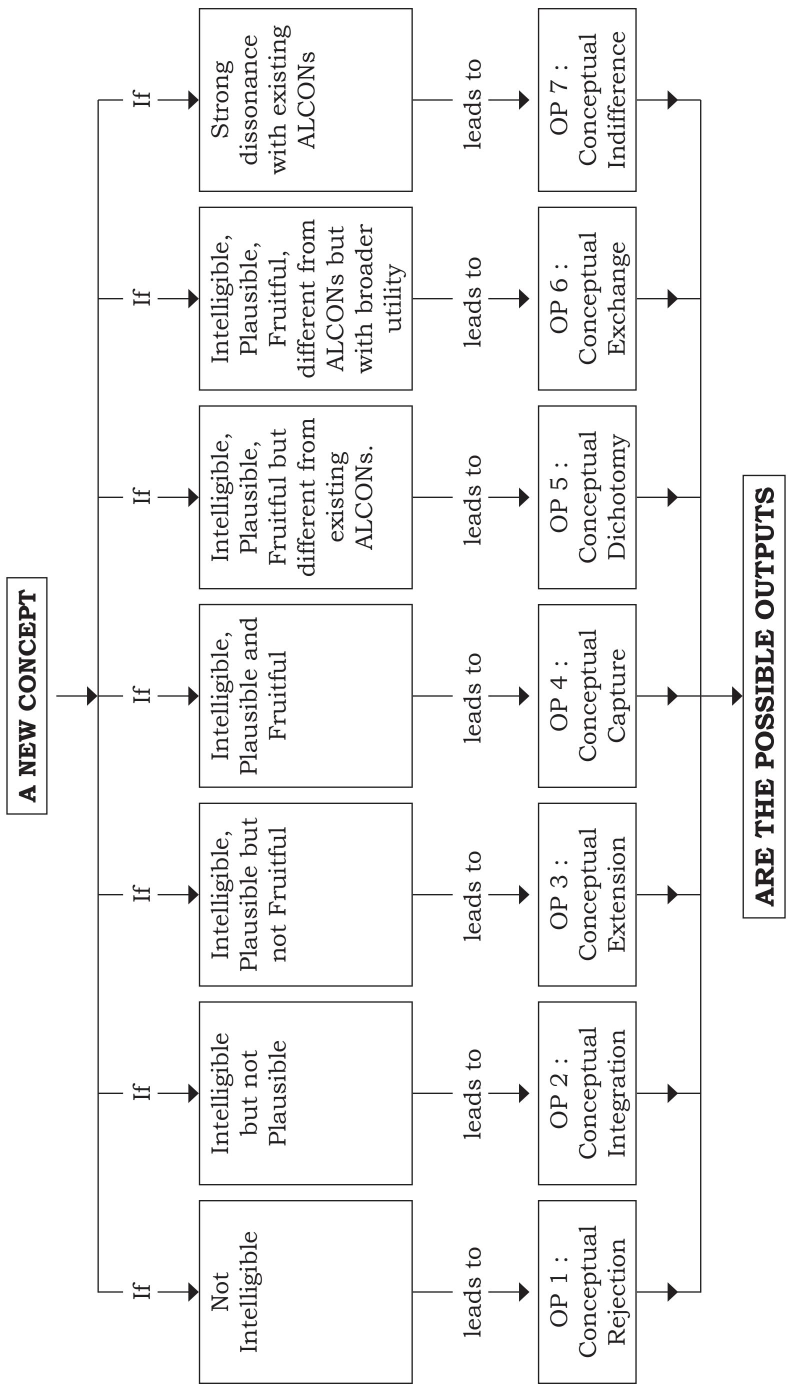
A NEW CONCEPT
If
Not Intelligible
Intelligible but not Plausible
Intelligible, Plausible but not Fruitful
Intelligible, Plausible and Fruitful
Intelligible, Plausible, Fruitful but different from existing ALCONs.
Intelligible, Plausible, Fruitful, different from ALCONs but with broader utility
Strong dissonance with existing ALCONs
leads to
OP 1 : Conceptual Rejection
OP 2 : Conceptual Integration
OP 3 : Conceptual Extension
OP 4 : Conceptual Capture
OP 5 : Conceptual Dichotomy
OP 6 : Conceptual Exchange
OP 7 : Conceptual Indifference
ARE THE POSSIBLE OUTPUTS

Figure 3

Conclusion

In a classroom TLP, the only two and most crucial human components are the teacher and the learner. The average teacher brings with him/her his/her conformist inputs whereas the learner brings with him/her his/her constructivist inputs. Since the efficacy of a TLP is measured not by the quality of teaching but by the quality of learning, any input by the teacher will have functional meaning if and only if it works in consonance with the learner's constructivist inputs and endeavour and guides the learner to an output which best approaches the envisaged output of the formal schooling process. In the framework of the above mode, this optimisation of learning demands that the following steps be taken:

- A class-wise assessment of the MDL of the learners be undertaken so as to provide crucial statistical picture to curriculum framers and textbook writers.
- The cognitive demand of concepts that are to be included in the curriculum for each class, be undertaken to provide informative bench-marks to curriculum framers and textbook writers.
- The learner's ALCONs in each concept domain be diagnosed and mapped to help the teachers to plan teaching strategies.
- If possible genesis of the ALCONs of a group of learners be identified.
- Steps be taken for mass orientation of all personnel involved, right from the planning to curriculum framing to textbook writing to classroom teaching to evaluation, about the constructivist approach and this learner-centered input-output model.
- Teachers may be apprised of the cognitive preference modes so that they may try to adopt methods which will help the learner to go from the 'Recall' mode to the 'Principle' mode.
- In all teacher orientation programmes emphasis may be put on the 'Conceptual Change' model and the seven possible outputs with the aim in view to impress upon the teachers to use strategies so that the outputs like 'Conceptual Rejection' or, 'Conceptual Indifference' are never manifested.

We have presented here a four dimensional input and made an effort to provide key information for the measurement and/or use of the inputs in a classroom situation. The outputs have been delineated in the conceptual change model of the constructivist approach. It is hoped that this usable model will initiate the much needed step towards a functional and pragmatic composite model.

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