MUTUAL COMPARISON RECEPTION MODEL (MCRM) OF CONCEPT DEVELOPMENT IN SECONDARY SCIENCE LEARNING: A VARIATION TO BRUNARIAN THEORY.

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Key Words

Information Processing, Cognitive Structuring, Models of Teaching, Mutual Comparison Reception Model(MCRM) , Science Learning, Concept Attainment Process, Labeling, Examples of Concepts.

Abstract

The paper is the outcome of an experiential learning episode encountered by a teacher educator (the author) with a group of student-teachers under his mentorship during a session of the practice teaching programme (2006-07) at the secondary school level. The crisis faced by a student teacher in connection with the development of a lesson template based on Brunarian theory of concept development and Joyce and Weil's formulation of Information Processing Family of Models of Teaching turned out to be an occasion of *Eureka* to construct a new version of Concept Attainment Model (CAM) of teaching. Here the practitioners involved in the exploration proposes a twist to Concept Attainment Model of teaching, namely Mutual Comparison Reception Model of CAM, which seems to be highly suitable for the learning of those secondary level science concepts which are interlinked in the conceptual ladder. The field level experiences of the student teachers with the proposed model of teaching (2007-09) are also reviewed in the paper. The paper also annexes a selected lesson template developed by the student teachers based on the proposed model.

Introduction

Models of Teaching are largely used as fond area of innovative instructional strategies in today's classroom practices. Being strategies designed to provide suitable learning experiences resulting in the reorganisation of the cognitive frame work of learners, each model of teaching is designed with specific objectives in its functional architecture. In fact models of teaching are basically framed to act as models of learning. Studies on the comparative effectiveness of two or more models of teaching using an experimental design are plenty in educational research. Attempt to identify and test the scope of a selected model of teaching across various conceptual tracks of the same subject or the viability of applying a model of teaching across different age levels of learners is rarely attempted. The paper portrays the collective experiences of a group of Physical Science student-teachers along with their mentor during a phase of their practice teaching in 2006-07, the outcome of which was further analysed and confirmed in the successive years. The paper does not follow a strict structural framework of a research reporting in behavioural sciences and humanities taking the freedom of qualitative research approaches.

A Note on the existing Practice of Bruner's theory in Science Classes

Jerome S. Bruner developed his theory of concept attainment. He used his *card experiment* to postulate the general strategies by which pupil employ to develop concepts. I his experiment, the cards bearing differently shaped centre figures in different colours - primary and secondary, with and without borders were used. Thus the design of the cards used an attribute value of four: *figure shape, figure number, figure colour* and *presence and absence of borders*. Bruner put forwarded four pathways for concept attainment: **Simultaneous Scanning** (*maintenance of attribute values of all positive instances in memory to deduce further positive cases from the incoming samples*), **Successive Scanning** (*maintenance of an overall estimate of the correct sequence of attributes of the concept leading to testing of characteristics one at a time when a new case comes*), **Conservative Focusing** (*checking of each instance in comparison with a case which is in short of only one attribute from that which is being tested*) and **Focus Gambling** (*checking of each instance in comparison with a case which is in short of two or even more attributes from that is being tested*).

While framing the Information Processing family of Models of Teaching Joyce, Weil and Showers took the theoretical framework of Jerome Bruner to design the Concept Attainment Model (CAM). A significant feature of the adoption of the theory in the model is the direct utilization of *Double Discrimination* – discrimination between the *essential attributes* and *non-essential attributes* and discrimination of *positive examples* from the *negative examples*. The cognitive structuring of the developing conceptual frame work of a learner will be conditioned and reinforced by this double discrimination process.

The present practice at classroom application of Concept Attainment Model follows two modes namely: *selection* and *reception*. In the former the teacher presents unlabelled examples of the concept followed by the selection of concept instances by students leaving the full responsibility of concept tracking and mental structuring of the concept to students themselves, while in the latter the examples of the concepts are labeled with signs like 'Yes' or 'No' to accept or reject an example

leading to hypothesisation by students to establish a learning trajectory of discovery. The investigator and the team of student-teachers in their work used the reception strategy of CAM, the syntax of which is summarized as below:

Phase I: Presentation of Data and Identification of Concept

- Presentation of labeled examples by Teacher
- Comparison of attributes of positive and negative examples by students
- Formulation and testing of hypotheses by students
- Formulation of statement of the definition based on attributes by students

Phase II: Testing of Attainment of Concepts

- Identification of additional examples from the given unlabelled examples
- Confirmation of student hypotheses by teacher
- Naming of the concept by teacher
- Restating of the concepts according to the essential attributes by the teacher
- Generation of further examples by students

Phase III: Analysis of Thinking Strategy

- Description of thoughts by students
- Discussion on the role of hypotheses and attributes by students
- Discussion of the types and number of hypotheses by students
- Evaluation of the strategies by teacher

While practicing the reception mode of CAM in the classroom, the third phase seemed to be slightly difficult due to the fact that a good number of students in an ordinary secondary class are not effective evaluators of themselves in their learning style. The circumstance may be largely due to experience of traditional learning habits in the classrooms.

Objectives

At the time of presentation/publication of the findings of this classroom action based innovation, the objectives of the whole exercise can be summarised as below:

1. To report the innovative classroom practice which turned out to be an interesting incident of addition to educational theory from the career practice of the investigator
2. To collect academic support from different part takers involved in the investigation process
3. To generate constructs as a theoretical base to rectify the inadequacy of Brunarian Concept Formation Strategy as applied in reception mode of Concept Attainment Model.
4. To develop lesson templates based on Mutual Comparison Reception Model of Concept Attainment in collaboration with Student-Teachers who functioned as part takers in the innovation process.

The Contextual background of the present invention

The insight evolved in proposing a variant to the popularly accepted Concept Attainment Model (CAM) (Reception mode) of teaching was the outcome of an interesting episode from the curricular experience of the investigator. During the second phase of the practice teaching session it is mandatory for the student teachers to prepare two or three lesson templates based on selected models of teaching of their choice, as per the revised curriculum of B.Ed. of University of Kerala. The Models of Teaching generally selected by the student teachers under the mentorship of the

investigator at their College of Teacher Education in Thiruvananthapuram (2006-07) were Concept Attainment Model (CAM), Inquiry Training Model (ITM), Advance Organiser Model (AOM) and Role Playing Model (RPM) (*a la* Joyce and Weils). A Student-Teacher (*Mr.AnurajB.R.*) who prepared a lesson template using CAM on circular motion and its types approached the investigator for a discussion. The student teacher's attempt was to develop the concept of *Rotation* after introducing the general idea of circular motion for which the tri-step syntax[1]*of the reception mode of CAM was attempted. The interaction turned out to be an occasion of insight both for the investigator and the student to examine the insufficiency of Brunarian approach to concept development with a modified version of lesson template.

Methodology

The general methodology of the study coincides with the descriptive and analytical paradigm of qualitative research of social sciences, humanities and educational sciences. Experiential observation and participant analysis played a major role in the insight gained/ discovery of the proposed variant of the model of teaching. The practical wisdom accumulated during the process of investigation led to the identification of the insufficiency of the Brunarian theory of concept attainment. Mentor-student interaction in small and large groups helped a lot to formulate components of the modified version of the model. Critical Reflection-On-Action was also attempted during the conceptual development of the new model. Critical reading, analytical observation, interactive discourses and theoretical modeling cum construct making also got intertwined with the reflection-in-action process to formulate the conceptual frame work of the proposed variant of the Brunarian theory of concept formation. Triangulation in terms of Expert Level Discourse, Peer De-Briefing and Student-Teacher Led Field Level Application added to the trustworthiness to the model developed. Document analysis and inferential scanning of downloaded material from internet resources also contributed in the process of reviewing of supportive literature during the preparation of the report.

Findings/Conclusions: During the correction part of the lesson template brought by the Student-Teacher on Rotation/Revolution, the investigator found that the student-teacher developed his lesson transcript by taking cases of rotation as positive examples and cases of revolution as negative examples of rotation. While following the syntax of the reception mode of CAM the attempt by Student-Teacher was correct. The discussion initiated by the investigator was on what items could be included as positive and negative examples while developing the concept of revolution. Naturally the conclusion evolved was that the cases of revolution will be taken as positive examples and that of rotation as negative examples. Even though technically the syntax of the CAM is satisfied the two cases cannot be handled separately as both rotation and revolution falls as sub-concepts of the major concept of Circular Motion. In many natural cases even the same bodies undergo both rotation and revolution simultaneously resulting in many different phenomena. This led to the failure of the proof for Simultaneous or Successive Scanning or Conservative Focusing

[1] **Tri-Step Syntax**: Presentation of labeled examples, Presentation of unlabeled examples and Verification of concept development and Analysis of the conceptualization process

attempt of concept formation procedures as proposed by Bruner. The investigator recommended a restructuring of the lesson template by taking rotation-revolution concepts together thereby taking the cases of both rotation and revolution as positive examples. The investigator also suggested re-naming the model as Mutual Comparative Reception Model of Concept Attainment. The investigator later communicated this creative episode to his research mentor N. Vedamani Manuel, who in spite of being a great proponent of Brunarian theory approved the insufficiency of the theory at higher Levels of learning and validated the arguments put forwarded by the investigator.

The elements of innovation arrived during the course of the investigation are listed below:

1. Brunarian concept formation strategies are insufficient to fully illustrate the concept formation in science at Secondary/Higher Secondary levels.
2. Even though individual concepts at the lower levels of learning can be effectively illustrated using reception mode of CAM, inter-related concepts which may fall as sub-concepts of a major concept must be dealt with using a different style of CAM.
3. At secondary and above levels of science learning while applying Brunarian theory through CAM, a thorough concept level analysis of the Structure of Knowledge is essential. Those conceptual patterns which are closely interrelated and mutually dependant in terms of their attributes and attribute values must be identified to escape from the aberration of creating conceptual conflict in the minds of learners.
4. A generalized application of Reception Mode of Concept Attainment Model taking interrelated concept pairs as a single sub-unit for a lesson template is non-functional.
5. In Phase I of the reception mode of CAM, instead of placing examples as positive and negative ones, those examples of mutually complementary science concepts can be titled as 'positive examples' (Indicating Y_1 and Y_2 instead of Y and N).
6. A positive-positive example comparison will lead to '***parallel comparative scanning'*[2]*** of attributes of inter-dependent concepts will lead to more cohesive conceptual development.

Two other student-teachers of the same academic year (Suresh Kumar S. and Sabitha R.S.) also successfully attempted the Mutual Comparative Reception Model of Concept Attainment during their practice teaching on topics like *Short Sight and Long Sight* and *Properties of Ionic and covalent Compounds*. In the successive years (2007-08 and 2008-09) also the student-teachers followed the modified version of CAM during their practice teaching. In 2008-09 another student-teacher (Uma M. G.) collected the practical utility of Mutual Comparison Reception mode of CAM over other models of teaching as part of her individual practicum fulfilling the requirements of the teacher education course. She made a personal micro level analysis of the practical advantages of Mutual Comparative Reception Mode of CAM. She interviewed (unstructured) 19 fellow student-teachers of her class and interacted with her own science students (N=45) during the second phase of practice teaching (question cum discussion mode). On the utility side of the model, majority of the student-

[2] **Parallel Comparative Scanning:** Set of attributes is compared simultaneously in parallel pair at a time

Teachers opined that the Mutual Comparison Mode besides being time saving reduces the complexity of learning of concepts. Her discussion with the students also revealed that the perceptual understanding of the interrelated concepts, when formed through the model, gives greater clarity of attributes. (She used a lesson transcript on *Inertia of motion Vs. Static Inertia*).This effort contributed towards the triangulated validity of the findings of the study initiated by the investigator.

Table 1: Reception mode of CAM compared with Mutual Comparative Reception Mode of CAM

Reception Mode of Concept Attainment Model	Mutual Comparative Reception Mode of Concept Attainment Model
Isolated Single Concept is Presented	Inter-related Complementary Concept Pairs Presented
Examples are presented as a mixed case of Positive and Negative Ones	Both set of examples are positive, follows Positive-Positive mutual comparison
Information processing is through either simultaneous /successive scanning	Utilises a new pathway of Parallel Comparative Scanning
Chance for mechanical reception or rejection of attributes	Reception strengthens the structuring of knowledge contributing to meaningful construction of concepts
More suitable for lower level of science learning	Suitable for secondary/senior level science learning
Promotes Extrinsic Discovery	Permits Intrinsic Discovery

The investigator helped the student-teachers to frame their lesson templates based on Mutual Comparison Reception model of Concept Attainment since 2006-07; three of which were collected as part of the report preparation. The translated version of the lesson template developed by Anuraj B. R. (2006-07) is attached with this paper as Appendix 1.

Excerpts from the Personal Experience of Student-Teachers who practiced the New Model of Teaching

The following paragraphs give a general vision of the personal experiences reported by the Student-Teachers who practiced the Mutual Comparative Reception Model of Concept Development for the first time.

Anuraj B. R., with whom the design of the new model first evolved writes; '…Accoding to Bruner in all his procedure for Concept formation viz Simultaneous Scanning, Successive Scanning, Conservative Focusing and Focus Gambling, there is a comparison, reflection and assessing. Bruner suggests distinct positive and Negative Examples. Students will discard the negative ones and accept the positive one leading to concept formation.

…In my lesson template I thought to present the Positive examples of Rotation taking Positive examples of Revolution as Negative examples to Rotation and vice versa. But I felt that the concept formation cannot be done in a single phase as I thought to include both Rotation and Revolution in the same lesson template.…With

this difficulty in hand I approached my mentor with the copy of the lesson transcript. I was helped to identify the difficulties with the reception style approach of concept. ...The most difficult part of the lesson preparation was the selection of examples. As per my mentor's view, "while presenting rotation and revolution together there are no negative examples; instead there are only two set of positive examples". Here the student compares both, identify the attributes and accept them. There is no provision for 'rejection' as there no negative examples. So the example selection was much difficult. …the examples must be familiar and life related. More over they should not be abstract and complex. So I selected example covering demonstrations, interesting familiar toys, verbal illustrations etc.

…I had some doubts and tension during the application of the new model regarding students' capability for identification of right attributes and mutual comparison. So I adopted some preplanned strategies during the class. I gave verbal explanations of examples and encouraged them to have one to one comparison…As rotation and Revolution are inter-related concepts they must be attained simultaneously to have right conceptual pattern. The new model of Mutual Comparison Reception allows it easily. …it need some higher mental activities and can help in the simultaneous attainment of related concepts.

…I think the most significant effort is the presentation of examples to students….I tried to do the best I can….the response was surprising….When mixed examples were given in the second phase 70% of students were able to catergorise them to rotation and revolution… I have done it on a shortened period in the AN session of the school. If time of the class is arranged in the second or third period of the FN session the model could prove more successful…' The comments made by the student-teacher highlight the advantage of the new model with some indications regarding its further practice.

Suresh Kumar S., who practiced the new model of teaching taking the properties of Ionic and Covalent compounds wrote, '…Properties of ionic and covalent compounds are interrelated topics…through the suggestions obtained from my mentor I realised that Mutual Comparison Reception Model is more useful to develop the concepts simultaneously…this approach needs more examples to present…After the categorization of mixed example I came to the conclusion that the model lead to more meaningful concept formation…and is more useful on attainment of concepts of interrelated and close topics…' The comments stress the need of applying the *parallel Comparative Scanning* in identifying attributes of interrelated conceptual components of the knowledge hierarchy.

Scope and Limitations

On the dimension of scope of the experience, the significant one is the academic confidence boosting the investigator and the associates experienced in the sense that even an Under-Graduate level Teacher Education classroom practice can lead to theory generation as a modification to an existing established piece of knowledge. The experience adds to the utilization of problem solving strategies to the emerging practical issues of applying pedagogical theories. It also offered a chance for the investigator and his collaborators to probe on an in depth understanding of the possibilities and limitations of the Brunarian theory leading to action research mode of investigation. Such experiences adds to the possibility of new platforms of knowledge sharing and collaborative effort leading to meaningful experience sharing and knowledge creation even within the limited academic horizon an Under-Graduate course in Teacher Education. The initiative also opened up a new venue for learning through doing which justifies the present academic pattern of practicum based learning. Also the same kind of work can be undertaken on a wider plane of research to assess the acceptability and practicability of the Model of Teaching formulated.

Since the findings were generated after observation of a series of classroom episodes as and when it occurred, a major limitation of the work is that it was not followed a systematically framed research design, which can be rectified by further investigation of the finding in the near future. The

Parallel Comparative Scanning process which is proposed to substitute the Brunarian four steps concept development pathways, in the new model teaching is at its hypothetical stage, the details of which must be elaborated through further analysis and experimentation. The real testing of the Positive-Positive comparison of examples in the mutual comparison reception model need substantial analysis to establish its authenticity, which was not covered in the current segment of the study. These areas even though exist as limitations of the study offer area for further research

Conclusion

As a Teacher – Educator who had always keen on paying attention to generate innovative practices in the classroom and initiate the student-teachers to such experiences counts this as a significant step in fostering his educational research career with a deep sense of commitment and enthusiasm. The Mutual Comparison Reception Model has to undergo the laborious process of amalgamation before it can be effectively implemented on a wider plane of subject faculties besides it being perfected in the field of science education. Mean while the model of teaching is expected to receive positive suggestions and academic acceptance through the platform of 97th Indian Science Congress.

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Appendix: The Lesson Template developed by Anuraj B. R. as per MCRM of CAM

Name of Teacher	:**Anuraj B.R.**	Name of school:	**St. John's Hr. S. School, Nalanchira**
Subject	:**Physics**	Std & Div.	:IX A
Unit	:**Motion**	Stage	: 13+
Sub-Unit	:**Circular motion-Types: Rotation & Revolution**	Date Duration	: 11.07.2007 : 40'

Content Analysis

Terms: Circular Motion, Rotation, Revolution, Axis

Facts:

1. A body moves in a circular path undergoes circular motion
2. Circular motion happens based on an axis
3. A body moves on a circular path has uniform velocity in constantly changing direction
4. The axis of a revolving body is outside the body
5. The axis of a rotating body is inside the body.

Concepts: Circular motion-Rotation and revolution

Definitions:

1. Rotation: If the axis of a body in circular motion is inside the body, it undergoes rotation.
2. Revolution: If the axis of a body in circular motion is outside the body, it undergoes revolution.

Essential Attributes:

Rotation	Revolution
1. Body moves in a circular path	1. Body moves in a circular path
2. Body moves based on an axis	2. Body moves based on an axis
3. The axis of rotation is inside the body	3. The axis of revolution is outside the body
4. Body doesn't change position during rotation	4. Body continuously change position during rotation

Examples:

Set Y_1: Rotation	Set Y_2: Revolution
1. A Rotating top	1. A revolving stone tied at the end of a string
2. Rotating a lemon on an inserted thin steel rod	2. Model of Solar System
3. A moving cycle tyre	3. An athlete running on a circular track
4. Motion of earth causing day and night	4. The motion of an artificial satellite

Principles of Reaction: Structured, Semi Structured and Loosely Structured atmosphere in the three phases respectively

Supporting System: A stone tied at the end of a string (revolution), Thermocole Model of Solar system(Revolution), Top (Rotation), A lemon inserted with a thin steel rod (Rotation), chart showing definitions of circular motion, rotation and revolution (as shown below)

CIRCULAR MOTION

THE MOTION OF A BODY WITH UNIFORM VELOCITY IN A CIRCULAR PATH WITH CONSTANTLY CHANGING DIRECTION

ROTATION

THE CIRCULAR MOTION IN WHICH THE AXIS OF ROTATION IS INSIDE THE BODY IS KNOWN AS ROTATION

REVOLUTION

THE CIRCULAR MOTION IN WHICH THE AXIS OF ROTATION IS OUTSIDE THE BODY IS CALLED REVOLUTION

Effect (Objectives):

The Pupil:

1. Understands the nature of the concept of circular motion and its types
2. Improves competency in concept building strategy through parallel comparative scanning
3. Defines specific concepts of rotation and revolution
4. Develops awareness on alternative perspectives through hypothesisation of the above concepts
5. Undertake inductive reasoning while framing definitions of rotation and revolution from the comparison of attributes and examples
   (*Objectives are modified version by the investigator*)

Syntax of the Model

Phase I: Presentation of data and Identification of Concept

To bring the concept rotation and revolution the teacher presents the following labeled examples. Then directs the pupil to compare the Set Y1 and Y2 to identify the attributes. Necessary oral explanations are provided by the teacher to recognise the characteristics and specialties of the examples provided.

Y_1	Y_2
1. A Rotating top	1. A revolving stone tied at the end of a string
2. Rotating a lemon on an inserted thin steel rod	2. Model of Solar System
3. A moving cycle tyre	3. An athlete running on a circular track
4. Motion of earth causing day and night	4. The motion of an artificial satellite

The teacher then directs the students to formulate and write hypothetical definitions of the generalized attributes obtained by parallel comparison of Y_1 and Y_2

Phase II: Testing of attainment of concepts

To check and assure whether the students developed the concept, the teacher gives the following mixture of unlabelled examples. The students are directed to categorise them on the basis of the attributes they have identified in the previous phase.

Categorise as Y_1 and Y_2

1. A spinning cricket ball
2. A boy on a moving giant wheel
3. Motorcycle riding in an acrobatic well(*Marana Kinar*)

4. A rotating fan
5. A body on the surface of a rotating body
6. A giant wheel
7. The blade of a mixer-grinder
8. Motion of leaves of a fan
9. Mud on the cycle wheel
10. Motion of the shaft of a motor

After the exercise by students the teacher helps them to label the categories and names them as rotation and revolution and writes the words on chalk board. Then the teacher probes them to identify more examples for each category and ask them to present their hypotheses on the statement of Y_1 and Y_2. After sufficient discussion teacher helps them to consolidate the definition of Circular motion-Rotation and Revolution by exhibiting a chart.

Further explanations are provided to correct their remaining doubts in the conceptual understanding.

Phase III: Analysis of thinking strategy

The teacher ask the following questions to probe their pattern of thinking and hypothesisation process

How you got the concepts 'rotation' and 'revolution'?

How many different types of definitions you framed for rotation and revolution?

Identify the statement that you formed came close to the final definitions you learned

The students explain the way and the mental activities they followed to reach the concepts.

Then the teacher ask the following questions for formative evaluation

1. What is circular motion?
2. What is rotation?
3. What do you mean by revolution?
4. Spell out the common features of rotation and revolution
5. Compare and contrast rotation from revolution

Then the teacher recapitulates the important points and suggests the following activities

Follow Up Activities

1. Make a table with additional example of rotation and revolution from daily life.
2. Analyse the circular motion involved in the atom structure you have already studied
3. Develop a thermocole model of rotation and revolution from your classroom activities