4. SCIENCE DISCOURSE IN TAMIL

4.1 Introduction

Discourse is an utterance or sentence, or sequence of utterances or sentences produced with a purpose of exposing some information or theme in an appropriate context. It is a linguistic entity made up of sentences or contextualized, functional, informative utterances. Generally utterances may be treated as contextualized or non-contextualized. Contextualized utterances have meaning or significance and communicative value since they are produced in a context for realizing a specific communicative act. Non-contextualized utterances have meaning but may not have communicative value, since they are produced not in relation to a specific context. Discourse utterances are contextualized and functional and hence they have meaning, communicative value and contextual relevancy.

Discourse is created with the purpose of developing and sequencing propositions or meaningful utterances, circumscribing one or more communicative acts and hence the utterances of a discourse are cohesively organised. Discourse is also created with the purpose of developing and sequencing a set of communicative acts which are realized through the sequencing of a set of utterances. Utterances
are produced making use of two acts namely 'focal act' and 'enabling act' [Widdowson, 1978]. Focal act is the act of exposing some message. Enabling act is the act of using different linguistic strategies for the exposition of some message.

4.2 Discourse Characteristics

Discourses, both written and spoken may arise due to the interaction or the act of exchanging information between speakers and hearers or writers and readers. So, discourses are characterized as interactive entities. Non interactive discourses are also found and in such discourses hearer or reader involvement and contribution will be minimal.

Discourses arise with the goal of actualizing the intentions and illocutions of the speakers and writers, through a careful choice of linguistic elements made and by sequencing such linguistic elements especially utterances in an appropriate manner. Hence discourses are considered as illocutionary entities.

Discourses are produced by way of sequencing a set of utterances which carry some specific thematic content. The kind of utterances chosen for the creation of discourse
reflect the choice of discourse which in turn governs the style, genre and register of discourse. Hence, discourses are characterized as linguistic entities reflecting stylistic, registral characteristics.

Discourses are created in specific contexts or domains. The contexts which form the background of the discourse production and interpretation and the context underlying the production and interpretation of the utterances of a discourse are classified as social context, psychological context and textual context (Halliday, 1973). The social context incorporates the social settings and the speech situation. Social setting is the physical and the actual setting of a speech community. Speech setting is the physical setting of speech. Both these settings govern the selection of the themes of discourse, the topic of discourse and the topic shift in discourse.

Psychological context is the mental state of the speakers, leaners, writers and readers and it incorporates the knowledge, experience, belief, attitude and expressive potential of the speaker, hearer, reader or writer. Psychological context helps in carrying out the interaction, in making inference during interaction, in creating and comprehending utterances of discourses. In general, context
carry both verbal and non-verbal elements.

Spoken discourses are primarily made up of spoken utterances. Besides spoken utterances, spoken discourse carry non-verbal features such as gesture, facial expressions, body movement, etc., of speakers and hearers.

Written discourses are primarily made up of written sentences. Besides written sentences, non-verbal features like figures, charts, tables, symbols, underlines, italics and punctuation marks like comma, quotation marks, etc., appear in written discourse.

Spoken and written discourses are further classified as interactive and non-interactive on the basis of the involvement of participants. Non interactive discourses arise due to the effort of speakers or writers. Interactive discourses arise due to the combined effort and contribution of verbal behaviour made by speakers and hearers, and writers and readers.

Discourses can be classified on the basis of macro communicative act underlying the creation of discourse and also on the basis of the domain from which the information is drawn for discourse. Narrative, expository, hortatory discourses are communicative act based discourses. Literary
discourse, religious discourse, legal discourse, science discourse, etc., are domain based discourses.

It is often felt that science discourses are different from other discourses. Science discourse exposes objective facts in a non-aesthetic, non-emotive way and hence it makes use of the language in a representational way.

Science discourse

Science discourses are produced to represent common scientific concepts and procedures (Widdowson, 1978). They are produced for exposing scientific truths and the ways of arriving at scientific truths. They are homogeneous and constrained to a greater extent and they reflect certain special features. They are created to realize a set of communicative acts such as defining, describing, instructing, exemplifying. Scientific phenomena objectively and hence the purpose for which science discourses are created is delimited.

Science discourse can be assumed to be showing both deep and surface structures (Widdowson 1978). Deep structure of discourse is the conceptual organization of scientific information. Surface structure of a science discourse is the expression of the conceptual organization of scientific information through various languages.
Science discourse can be classified as (1) Discourse related to scientific research (2) Discourse related to science education and (3) Discourse related to the popularization of science among the mass.

Research oriented science discourses are written by researchers and scientists in a formal style for exchanging up-to-date information about science research findings among scientists. Science education discourses are written by writers for introducing science to and popularizing science among laymen.

Science discourses are also classified as discourses of science exposition, discourses of science inquiry. The former discourse is found in science text books and popular science writings. The later discourse is found in science journal.

4.3 Science discourse in Tamil

Science discourse written in Tamil are predominantly expository in nature. They expose scientific information drawn from science writings found in the international circles making use of Tamil language for expression.

Any science discourse is characterised by structural
and functional organisation. Structural organisation is reflected through the basic units composing science discourse (utterances or sentences) and the mode of sequencing of the basic units. Functional organisation is reflected through the basic functions or goals for which science discourses are created. Functional organisation of science discourse is realised through the sequence of sentences used in science discourse. The structural and functional organisation are identified as rhetorical technique and rhetorical function (Trimble, 1985).

Tamil science discourses are created with the purpose of exposing objective, empirical, universal, scientific facts, through the medium of Tamil. One could find Tamil science discourse is also characterised by structural and functional organisation. The way in which the scientific facts are expressed and organised through Tamil is exposed and illustrated with, the examples drawn from Science writings found in Tamil.

4.3.1 Organisation of science discourse in Tamil

Science discourse in Tamil shows structural organisation (Formal structures), contextual and theme organization (thematic structure) and functional organisation. Formal organisation is identified as
rhetorical techniques and functional organization is identified as rhetorical function.

4.3.1.1 Formal organization

Formal organization of science discourse in Tamil is obtained by identifying the utterances composing the discourse and the principles of sequencing the utterances of science discourse are classified as natural principles and logical principles. Natural principles of sequencing the discourse utterances are further classified as temporal principles, spatial principles and causal principles. The logical principles of organization of discourse utterances are further classified (1) Principles of importance (2) principles of comparison (3) principles of analogy (4) principles of exemplification and (5) principles of visualization (Trimble, 1985).

These principles of organization of discourse or utterances of discourse are found in the science discourse in Tamil and they are illustrated with due examples drawn from Tamil science writings.

4.3.1.2 Temporal principle of organization

This principle is one the principles used while organising the form of science discourse. It is realized
through discourse and paragraphs of science discourse, when the utterances of science discourse expose the succession of scientific events and activities giving importance to time which is either chronological or process time. Temporal principles of organization is used in science discourse for writing the history and development of scientific concept (chronological) and while writing the conduct of an experimental investigation (process time).

On translating the following discourse fragment in Tamil one could find that the first utterance reveals an event which happened at time \( T_1 \) and the second utterance reveals a related event which occurs after \( T_1 \) i.e \( T_2 \).

\[ T_1 \rightarrow T_2 \]

\( T_1 \) making astronomical observation in 2000 B.C.

\( T_2 \) publication by Ptolemy in 2nd A.D.

\[ T_1 = u_1 \]

\[ T_1 = \text{B.C. } 2000 \text{ an}^{\text{th}} \text{alavile:ye ci:narkal mutal va:niyal pative:}^{\text{th}} \text{ukalaic caytullatakai}.... \]

'The Chinese made the first astronomical observation as early as 2000 B.C.'

\[ T_2 = u_2 \]

\[ \text{....mutal a:ywuk ka}^{\text{th}} \text{turai onrai cuma:r A.D. iranta:m nu:ra:ntil ta:ami veliyitta:r} \]
'the first authoritative treatise was published by Ptolemy in 2AD.' (...p 11)

1 Spatial Principle

Spatial principle is the principle of explaining the spatial relationship between the components of scientific objects. It is reflected by the utterances describing the special organisation of the components of scientific objects and experimental gadgets.

In the following discourse fragment utterance one is used to show the relationship between the resonance column and the vertical board. The second utterance is used to explain the spatial relationship between the resonance column and reservoir of water.
column and reservoir of water.

\[ u_1 = \text{exposes the attachment of resonance column with a vertical board.} \]

\[ u_2 = \text{exposes the connection of resonance column with the reservoir of water through a rubber tube.} \]

Example: \( u_1 = \text{ottatirvuk karuvi... itu ta: iyil} \)
(Resonance column) (it) (with a vertical board)
poruttappatullatu.
(is fixed)

\[ u_2 = \text{ki:ppuram rappark kula:yn mu:lam ni:rulla} \]
(lower end) (rubber) (tube) (through) (have water)

ce: makkalattutan inaikap patullatu
(with reservoir) (connected)

2 Causal principle

This principle is used while describing the functional characteristics of scientific phenomena, objects and activities. It is revealed by science discourse when the utterances of science discourse are used to expose the cause and effect related to the process and action of a chosen scientific phenomena.

The following fragment of science discourse in Tamil reflects the ordering of utterances reflecting the cause and effect related to the formation of 'Stationary waves'. The following is the graphic representation of the cause and effect exposed in the science discourse. \( (C = \text{cause,} \)
\[ E = \text{effect}) \]

\[ C_i + E_i = C_2 \]

Creation of waves \( E_i \) = reflection of stationary waves.

\[ C_1 + E_1 = C_2 \]

Superimposition of \( E_2 \) = formation of waves chosen stationary waves.

In the chosen discourse, utterance one exposes \( C_1 \) and \( E_1 \). Utterance two exposes \( C_2 \) and \( E_2 \).

\[ u_1 = \text{ottatirvuk kula:vin tiranta munaiyil (Resonance tube)} \]

\[ \text{nettalaikalai erpattinta:1 (C}_1 \) \]

\[ \text{(longitudinal waves) (if created)} \]

\[ \text{atu mu:tiyapakuyil paatlu etirolikkiratu (E}_1 \) \]

\[ \text{(that closed end having touched reflect's)} \]

\[ u_2 = \text{munne:rum alaivyum, tiruppappattha alaivyum (incident waves)} \]

\[ \text{(reflected waves)} \]

\[ \text{megporuntuvata:1 (since superposed) (C}_2 \) + \]

\[ \text{nilaiya:na alaikal to:nrukinrana (E}_2 \) \]

\[ \text{(stationary waves) (appear)} \]

Science discourse

Utterance 1

cause

Utterance 2

effect

cause

effect

3 Logical Principles

Logical principles of organizing the science discourse structure are further classified as (1) the principle of
order of importance (2) the principle of comparison (3)
principles of analogy (4) principle of exemplification and
(5) principle of visualization.

4. The principle of order of importance

It is revealed by science discourse when utterances
of science discourse are sequenced in such a way as to
expose scientific facts giving order of priority to the
exposed content. For example defining a scientific
phenomena first and then giving due illustration to the
defined phenomena is a mode of sequencing utterances of
science discourse that reflects the order of priority and
the principle of the order of importance. Explaining the
structure of an experiment gadget and subsequently
explaining the ways of conducting experiments also reflect
the principle of order of importance. In Tamil science
discourse many examples are found which reflects the
sequencing of utterances on the basis of the principle of
order of importance.

In the following discourse fragment which contain
three utterances, the first utterance defines the concept's
'transverse wave' and the second and third utterances expose
the appropriate examples for transverse wave. The
organization of the following discourse can be presented in the following way.

Science discourse

U₁
- Definition
  - Transverse wave

U₂
- Example
  - Water waves, Stretched string

U₃
- Example
  - Electro magnetic wave

Utterance 1: o:r uːtàkattilūlla alai viraiyum ticaikkuc cen-kuttaːka uːtàkattilūlla tukaːkal ciːriyalpu iyakkattil irutāːl viraiyum alai kurukkalai enappaṭum.

"If the particles of the medium, vibrate perpendicular to the direction of propagation of the waves it is known as a transverse wave".

Utterance 2: niːr maṭṭattin miːtu untaːkum alaikaːl, iḷuttukkuṭṭapaṭṭa kampiyiːl eːptaṭum alai iyakkam kurukkalaikkku utaːraṇaṅkalaːkum

'Waves produced on the surface of water and in stretched strings are examples of this type of motion'.

Utterance 3: miṅkaːnta alaikaliṅ iyakkamum kurukkalaikkku utaːraṇam aːkum

'Electromagnetic waves are also transverse in nature'.
5. The principle of comparison and contrast

It is a principle of keeping two scientific phenomena in comparison and contrast and it involves the process of providing contrastive and comparative features of two scientific phenomena. It is revealed by the utterances of science discourse when they are used to expose the comparative and contrastive features of two scientific phenomena. Many examples could be drawn to illustrate the use of this principle in the science discourse written in Tamil.

The following discourse fragment compares two kinds of conductors and their features. The organisation of this discourse fragment is presented through the following figure.

\[
\begin{array}{l}
\text{Comparison} \\
(\text{object 1}) \quad (\text{object 2}) \\
O_1-U_3 \quad \text{good conductor} \quad \text{poor conductor} \quad O_2-U_3 \\
O_1-U_1 \quad \text{conducting large} \quad \text{conducting small} \quad O_2-U_1 \\
\quad \text{quantity of heat} \quad \text{quantity of heat} \\
O_1-U_2 \quad \text{Having a large} \quad \text{having a small} \quad O_2-U_2 \\
\quad \text{thermal conductivity} \quad \text{thermal conductivity} \\
U_1 = \text{cila poruṭkal perumalavu veppattai kaṭattukinṟana.} \\
\quad \text{'Some substances conduct a large quantity of heat'} \\
O_1 U_2 = \text{avai mikunta veṟpaṅ kaṭattu tiranai koṇṭulḷana} \\
\quad \text{'they have large thermal conductivity'} \\
U_3 = \text{avai narkaṭattikaḷ} \\
\end{array}
\]
The principle of analogy is revealed by utterances of science discourse when they are used to expose analogical phenomena. It is reflected during the process of giving similar examples for a particular scientific phenomena. The following discourse fragment reveals the analogical examples illustrating movement of certain objects in 'circular path'.

\[ U_1 = \text{cila poruṭkal ciritalavu veppattai katattu} \]
\[ U_2 = \text{avaì kurainta veppaŋ kaṭattu tirannai kontullana} \]
\[ U_3 = \text{avai aritirkatattikal} \]

6. The principle of analogy

'they have a small thermal conductivity'.

'they are poor conductors'.

We will study about bodies which move along a circular path'
utterance 2: puviya:ṇatu cu:riyanaic curri oru vaṭṭappa:taiyil iyaṅkukiṟatu ....
'earth moves around the sun along a circular path'.

utterance 3: Katiṅram onrin u:cal vaṭṭaviyal pa: tai onril iyaṅkukiṅratu
'the pendulum of a clock moves: to and fro along a circular path'.

In the above discourse, utterances 2 and 3 are analogical examples depicting the movement of bodies in a circular path about a fixed point as a centre.

7. The principle of exemplification

It is the principle of giving illustration and examples for the described scientific phenomenon. It is revealed by fragments of science discourse.

Example: \( u_1 \): cila poruṭṭkal ciṟitaḻavu veppattai kaṭattu kinraṇa
'some substances conduct small quantity of heat'

\( u_2 \): avai aritir kaṭattikaḷ
'they are poor conductor's.

\( u_3 \): kāṉṇaṭi, rappar, maram, epoṅnaṭi, poṇra poruṭṭkal aritir kaṭattikaḷa:kum
'non-metals like glass, rubber, wood.'
ebonite etc., are poor conductors'

In the above discourse, utterance (1) and (2) are used to define poor conductors and utterance (3) is used to show examples of poor conductors.

8. Visualization principles

This is a principle of giving visual representation to substantiate verbal information. It is made use of in science discourse while exposing the experimental gadgets, circuits etc., The act of giving visual representation is indicated in science discourse through the use of some set phrases.

Phrase pattern 1:

Paṭam X-il Vilakkappatuṅkiraṭatu 'is explained in fig X'
   " " Kaṭṭiyullā vā:ru 'as shown in fig X'
   " " iruntu 'from fig X'
   " " ka:npatu po:la 'as shown in fig X'

Phrase pattern 2:

Patam X kurikkiraṭatu 'fig X shows'
Patam X kaṅka 'see fig X'

The following discourse fragment shows the use of both the verbal utterances and visuals.
4.3.2 Rhetoric function

Science discourses contain various passages reflecting the purpose for which the information related to science is presented. The purpose behind the creation of
science discourse is generally termed as the rhetorical function of the discourse. Rhetorical function is the communicative act through which information related to science is presented in science discourse. These acts are classified as definition, description, classification, instruction and visual presentation (Trimble, 1985).

4.3.2.1 Definition

Definition is the act of defining or characterizing scientific phenomena in a simple or a complex way. Normally any definition carries two components namely the name or technical term of the chosen scientific phenomenon and the defining characteristic features of the scientific phenomenon. Definitions are classified as Formal, semiformal and non-formal definitions (Trimble, 1985) or as real and nominal definitions (Widdowson, 1980).

1. Formal definition

Formal definition is the act of giving precise information about scientific phenomena by pointing out almost all the characteristic form and functions of scientific phenomena. Most of the formal definitions are revealed through the linguistic options made through the selection of certain verbs. The following expressive
Eight formats are found in definitions (1) Description + Technical term + enapptəm (verb) (2) Description + enpatu (verb) + Technical term. Most of the definitions end in the following way.

| Technical term + ena alaikkappatukiratu | (p214) |
| Technical term + enappatum | (p170) |
| Technical term + enappatəna | (p189) |
| Technical term + enappatukinrana | (p234) |
| Technical term + a:kum | (p141) |
| Technical term + enkiro:m | (p235) |
| Technical term + enpa:r | (p229) |

Some examples of definitions making use of pattern (1) are the following

1. enpate + Technical term (p236)


'The rate at which the radius vector sweeps the angle is called the angular velocity'.

'The distance between any two successive particles in the same phase' is...

3. Kuvarrtsu, ka:laicit enpanavarril ore o:ru
Oliyiyal accuta:n unto. ippatikankalai
O:raccup patikankal enpa:r

'Quartz or calcite posses only one such direction (optic axis). They are called uniaxial crystals'

By comparing the definitions illustrated above we could identify the involvement of the technical term and the description in the following way.

<table>
<thead>
<tr>
<th>Technical term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>alaktum ko:nam</td>
<td>alaktum ko:nam</td>
</tr>
<tr>
<td>alaiyevulla to:laivu</td>
<td>alaiyevulla to:laivu</td>
</tr>
<tr>
<td>o:reovu oliyiyal accu</td>
<td>o:reovu oliyiyal accu</td>
</tr>
<tr>
<td>ulla patikam</td>
<td>ulla patikam</td>
</tr>
<tr>
<td>2d sinθ = nλ</td>
<td>2d sinθ = nλ</td>
</tr>
</tbody>
</table>

2. **Semiformal definition**

Semiformal definition is the act of giving less precise information about scientific phenomena by providing some of the characteristic features of them. In this
definition also the components namely technical term and description will be found.

<table>
<thead>
<tr>
<th>Technical term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Ka:raminkalam</td>
<td>amilaminkalattaivita leca:nanatu</td>
</tr>
<tr>
<td>'alkali cell'</td>
<td>'It is lighter than acid cell'</td>
</tr>
<tr>
<td>2. i:tarveppanka:ti</td>
<td>J va:tiva ku:la:yakum</td>
</tr>
<tr>
<td>'Etherthermoscope'</td>
<td>'J type tube'</td>
</tr>
</tbody>
</table>

3. Non-formal definition

Non-formal definition involves the act of giving some information about the scientific phenomena by way of pointing out the non-characteristic features of the chosen scientific phenomena.

<table>
<thead>
<tr>
<th>Technical term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. hydro:lisis</td>
<td>nira:rpakuttal ena porujpa:tu</td>
</tr>
<tr>
<td>'Hydrolysis'</td>
<td>'means dividing through water'</td>
</tr>
</tbody>
</table>

4. Real definition

Real definition involves the act of giving the technical term of a scientific phenomenon first and then giving the defining features of the scientific phenomenon.

<table>
<thead>
<tr>
<th>Technical term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>'speed'</td>
<td>nera:rttil ka:takkum to:laivu a:ka:n</td>
</tr>
</tbody>
</table>
5. Nominal definition

In contrast to real definition, a nominal definition involves the act of giving the defining characteristics of a scientific phenomenon first and then giving the relevant technical terms subsequent to the defining features.

<table>
<thead>
<tr>
<th>Defining characteristics</th>
<th>Technical term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oh iyan'um tukal oru vina:ti</td>
<td>atan ve:kam (a:kum)</td>
</tr>
<tr>
<td>ne'rrattil kałakkum to:laivu</td>
<td>'is it's speed'</td>
</tr>
<tr>
<td>'The distance crossed by any moving body within a second'</td>
<td>'is the distance covered by any moving body within a second'</td>
</tr>
</tbody>
</table>

4.3.2.2 Description

Description involves the communicative act of describing or elaborating the features of scientific objects, activities and phenomena. Descriptions are classified as physical, functional, process descriptions (Trimble, 1985) or as structural and functional descriptions (Widdowson, 1980). Structural description defined by Widdowson is more or less equivalent to the physical description defined by Trimble and the functional description explained by Widdowson is more or less
equivalent to the process and functional description conceived by Trimble.

1. **Physical description**

Physical description involves the act of describing in detail the physical characteristics of scientific objects like the shape, size, texture and the spatial relationship of the components of scientific objects. Some examples of discourse passages which reflect physical description are the following:

mintalattil nermıňa:i etirmıňa:i ena
takatukal ma:rima:ri poruntiyullanä
'positive and negative plates are alternatively used in a cell'

In the above description, the structure of a cell is defined in terms of the filling of the positive and negative plates.

2. **Functional description**

It involves the communicative act of describing functional characteristics like the role, function, use etc., of the scientific objects. Example: ka:ma:kkatirkal minnu:ttam perřavai alla. avai oliyin tıcai vëkattutan.
gamma rays do not possess electric charge. They travel with the velocity of light. Gamma rays are more penetrative. Their ionising power is small. They affect photographic plates. They have discrete energies.

This description is a functional description because it gives the functions of gamma rays in the following way:

1) Not possessing electric charge (2) Travel with the velocity of light, (3) More penetrative in nature (4) Small ionising power (5) effecting photographic plates and (6) having discrete energies.

3. Process description

This involves the act of describing the processes undergone by scientific objects.
In thermopile, heat radiation falls on the set of blackened junctions. These junctions become hot. A thermo e.m.f. is set up due to the differences in temperatures between the two sets of junctions. This gives rise to a current which is indicated by a deflection of the galvanometer.

In the above example the process that occurs in or states that are assumed by the thermopile namely (1) becoming hot (2) occurrence of current (3) deflection of galvanometer etc., are described. Hence this description is a process description related to the thermopile in general and thermopile function in particular.

4.3.2.3 Instruction

Instruction is the act of making or asking the reader to carry out certain activities. It is classified as direct and indirect instruction (Trimble, 1985). It reflects the methods of doing certain activities and the effect brought by the activities.

4.3.2.3.1 Direct and indirect instruction

Direct instruction is the act of asking directly the reader to carry out certain activities step by step. It reflects
the use of imperative verbs in utterances.

Indirect instruction is the act of asking indirectly the reader to carry out certain activities. Discourse passages which function as indirect instruction reveal the use of passive verbs, model verbs and passive models.

1. ni:r puka:kalattil miŋtaŋaŋyattai vaittu
   ikkalattai oru nĩrtto ŭtjuŋul vaikka
   'Keep a resistance in a water tight cell and keep it in a tub of water'

2. ittojįįiyin veppanilaŋ ma:ra iyalum
   'The temperature of the cell can be changed'

3. toįįiyin veppanilaŋ kaničama:na neraŋ
   nilaiyurtti miŋtaŋaŋyattin matippai
   nilaiyurac ceyave:нтum.
   'The capacity of the resistance is standardized by standardizing the temperature of the cell for sufficient time'

4. ippati ceytapinnar anta veppanilaŋyil miŋtaŋ matippai nĩnayikkala:m
   'By this way resistance capacity is measured in that temperature'

5. itupo:nŋya vevvčru veppanilaŋyil miŋtaŋiya
   matippai alakkala:m
Likewise the resistance capacity value can be measured at different temperature.

In the above instructional passage the first utterance is a direct instruction and the rest are the utterances reflecting indirect instruction. The first utterance reflects the method and the last two utterances reflect the effect. This can be tabulated in the following form.

<table>
<thead>
<tr>
<th>Utterances type of instruction</th>
<th>Verbs used</th>
<th>method/effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Direct instruction</td>
<td>imperative verb</td>
<td>method</td>
</tr>
<tr>
<td></td>
<td>('keep' vaikka)</td>
<td></td>
</tr>
<tr>
<td>2. Indirect instruction</td>
<td>model verb</td>
<td>method</td>
</tr>
<tr>
<td></td>
<td>(iyalum)</td>
<td></td>
</tr>
<tr>
<td>3. Indirect instruction</td>
<td>model verb</td>
<td>method</td>
</tr>
<tr>
<td></td>
<td>(ve:ntum)</td>
<td></td>
</tr>
<tr>
<td>4. Indirect instruction</td>
<td>model verb</td>
<td>effect</td>
</tr>
<tr>
<td></td>
<td>(nirnayakkala:m)</td>
<td></td>
</tr>
<tr>
<td>5. Indirect instruction</td>
<td>model verb</td>
<td>effect</td>
</tr>
<tr>
<td></td>
<td>(alakkala:m)</td>
<td></td>
</tr>
</tbody>
</table>

4.3.2.4 Classification

Classification is the act of listing different scientific objects or phenomena which are perceived to be similar with regard to some features. It also involves the act of establishing the class-membership relation between
two or more scientific phenomena, identifying members belonging to a class and unifying two different scientific phenomena on the basis of the similarity in the characteristic features they manifest.

Classification of scientific phenomena may be complete or partial, implicit or explicit.

1. **Complete classification**

   This involves the classification of objects, process etc., by specifying them overtly in terms of their superordinate, subordinate nature and in terms of their similarity.

   1. alai iyakkattai iru perum pirivukala:kap
      pirikkala:m
      'The wave motion can be broadly divided into two types'
   2. avai(i) iyakkaviyal alaiiyakkam
      'mechanical wave motion'
      (ii) minka:nta alaiiyakkam
      'Electromagnetic wave motion'

   In the above discourse fragment the first utterance reveals the act of classification and the second utterance reveals the classified items.
2. Partial classification

It is the act of classifying scientific objects etc., implicitly without making overt statement of classification.

**Utterance (1)** palvēru pampukāl kantupitiikkap
pattu ullana
'Many types of pumps are invented'

**Utterance (2)** inku culal marrum viraval
pumpukalāippayri paṟṟṟo:m
'Here, let us see rotary and diffusion pumps'.

The above utterances reveal implicitly the existence of two types of pumps:

Classification is revealed through science discourse passages where some utterances show the expression of the act of classification. Some utterances show the items classified and some give the description of the items classified.

1. kaṟnakalai iru vakaikalakap pirikkala:m
'Bases can be divided into two groups'

2. niril atika alavu ayanikal:
kappiriyum. kaṟnakalai vi:riyam
mikunta kaṟnakal enkiro:m
'The bases which ionize in water completely or to a
higher quantity are called strong bases'.

3. ni:ril kurainta alavu ayaniya:kap
piriyum ka:rankalai vi:riyam kurainta
ka:rankal enkiro:m
'The bases which ionize in water to a lesser
quantity are called week bases'

In the above illustration the first utterance
reveals the act of classification. The second utterance
reveals one classified item and its description of it. In Tamil
science discourse there are overt phrases or linguistic
options reflecting the act of classification.

1. muvakai X ulna
'There are three types of 'X''

2. X iruvakaippatum
'X is of two types'

3. X ai iruvakaippatuttala:m
'X can be classified into two'

4. X pinvaruma:ru
'X is as follows'

5. X ai irantu nilaikalil payanpaṭṭtala:m
'X may be used in two ways'

6. X, X2, X3 ena mu:ru vakaippatum
'may be classified into three types as X1, X2, X3'
4.3.2.5 Reporting

Reporting is the act of giving information about a scientist, his discovery, year of discovery etc, making use of the direct or indirect forms of speech. It involves the act of quoting what scientists have said earlier about a scientific phenomenon. Reporting is reflected through utterances of science discourse.

The utterances which carry the function of the reporting, which reveal the information about scientists and their discovery are normally followed by utterances exposing information about the discovered scientific information or followed by utterance exposing still earlier discoveries made.

Issac Newton (1642-1727) was the first to put forward a theory on scientific basis to explain the nature of light. According to this theory a source of light or a luminous body emits, tiny, weightless, perfect by elastic particles called corpuscles'.
In 1862, Foucault designed an apparatus for the measurement of the velocity of light. Earlier experiments used celestial and terrestrial methods which could not give very accurate results.

In the above two examples the organization of information present in the utterances can be presented in the following way.

Example 1

utterance 1

utterance 2

4.3.2.6 Comparison

Comparison is the act of comparing objects, process, activities, scientists and scientific phenomena. It involves a look at characteristics, quality etc., of scientific phenomena and objects (Widdowson, 1980). Comparison also involves the selection of the basis for comparison which may be the form, function, quality and other characteristics of the items which are accepted as similar. Comparison is realized through utterances of science discourse. These utterances reveal the communicative act of comparing.
scientific objects and phenomena.

In the following discourse utterances the compression and expansion aspects of gases are presented in a comparative form.

1. vaːlvu onru amukkapatụm poːtu atan aluttam mikuntu parumān kuraikiratu.

'when a gas is compressed, its pressure increases and its volume decreases.'

2. uruvaːkkappatụ veppam veliyerrappatụvataːl veppanilai maːrāmal ullatu

'The temperature remains a constant as the heat produced is removed'.

3. vaːdvu onru virivatāiyum poːtu atan parumān mikuntu aluttam kuraikiratu.

'When the gas expands, its volume increases and its pressure decreases'.

4. puratteː āru veppattai eːrru veppanilai maːrāmal ullatu.

'The temperature is kept constant by taking heat from outside'.
The comparison of the content of the above utterance pairs (1,2 & 3,4) can be presented in the following way.

- Compression of gas
  - Pressure increases
  - Volume decreases
  - Heat passes out
  - Constant temperature

- Expansion of gas
  - Pressure decreases
  - Volume increases
  - Heat is taken in
  - Constant temperature.

4.3.2.7 Generalization

Generalization is the act of giving generalized characteristics of scientific objects and phenomena and this act is revealed by science discourse utterances. Such utterances may be followed by the utterances reflecting the act of giving specialized characteristics of scientific objects and phenomena.

Generalization is a act that determines the nature of the paragraphs found in science discourse. Paragraphs of science discourse may be classified on the basis of the place of the utterances reflecting the act of generalization and specification.

If a paragraph shows generalized information about scientific objects first and then exposes specialized information, it is called analytic paragraph. If a paragraph shows specialized information first and then
summarized the specific information by means of generalized information, it is called as synthetic paragraph (Trimble, 1985).

Utterances showing the act of generalization may be preceded by illustrations also. The act of generalization is revealed by expressive cues. Such as avva:re, ivva:re 'thus'.

   'When a gas compressed, its pressure increased and volume decreases. The temperature remains constant as the heat produced is removed'.

   'When the gas expands, its volume increases and its pressure decreases. The temperature is kept constant by taking heat from outside'.

   'Thus in an isothermal change, the temperature is kept constant by taking away heat from the gas or adding
heat to the gas.

In the above discourse the first paragraph deals with specific information about the compression of gases. The second paragraph deals with specialized information regarding expansion of gases. The third paragraph is the generalized paragraph and it establishes the maintenance of constant temperature during the process of compression and expansion of gases.

Paragraph 1 and Paragraph 2
Compression of gas Expansion of gas

Paragraph 3
Isothermal change

4.3.2.8 Explanation

Explanation is the act of giving information in detail about the structure and function of scientific phenomena. It is revealed by some utterances of science discourse in which one utterance may function as an introduction. Explanation utterances may be a series of utterances giving specific information about the structure and function of scientific phenomena. The utterances introducing the act of explanation is reflected by some cue phrases in Tamil. Vilakkalam 'can explain'.
Uiriva:kakka:npo:m 'let us see in detail' etc., are used as cue phrases.

1. Katirvi:cciṅ alava:ṅatu akkatir vi:cciṅ umilum parappin tanmai po:rutuḷatu
   'Radiation depends on the nature of the radiating surface'

2. itanai Leslie'yin kaṇaccaturattiṅ utaviya:1 vilakkala:m
   'This can be demonstrated by the Leslie cube'.

In the above discourse the first utterance reveals the nature of radiation. The second utterance introduces the way of demonstrating it. This utterance is followed by a paragraph depicting the structure and function of Leslie cube.

4.3.2.9 Assumption

Assumption is the act of assuming something and it is revealed through some utterances of discourse. These utterances reflect hypothetical stand taken with regard to some scientific information and they are followed by utterances revealing the act of experimenting and verifying the hypothetical stand taken. Very often in Tamil science discourse the verbal form[Kolvo:m] 'assume' functions as the cue for identifying the act of assumption underlying the
utterances.

"Thus in fig. 1.16 if A is the area common to layers B and D, $V_1$ and $V_2$, their respective velocities and $X$, the distance between them, then the viscous force

$$F \propto A$$

$$\propto V_1 - V_2$$

$$\propto \frac{1}{X}$$

or

$$F \propto A \frac{V_1 - V_2}{X}$$
In the above discourse the first part reveals the assumption regarding the area etc., and the second part reveals the method of finding the viscosity.

4.3.2.10 Initiating

Initiating is the process of giving general background information or widely known information before giving detailed information about scientific concepts. The utterances revealing initiation function as a preface to any description and point out the contrast of what is known, what is learned and what has to be learned.

'Last year you have learnt that sound is propagated through any medium in the form of waves. Now let us see what this propagation of sound actually means'.

In the above discourse the first utterance discloses what was already learned regarding sound. The second utterance reveals the topic to be learned namely propagation of sound.
4.3.2.11 Naming

Naming is the act of christening an observed scientific phenomenon. Names are normally given to the new concepts that are coming in science or to certain old concepts which are redefined. Naming also includes listing different names given to the same phenomenon by different people. Names are used to create interest in the readers and make readers compare the different writers' view about a scientific concepts.

The act of naming is reflected through certain utterances in Tamil science discourse and set phrases like *ena aḷai kappāṭukiratu* 'is called' are used to show the occurrence of naming activity. The discourse reflecting naming will carry the referential information, the technical term and the verbs used for naming.

<table>
<thead>
<tr>
<th>Referential Information</th>
<th>Technical term</th>
<th>Naming verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. <em>tiravāṅkālin urai vicaik</em></td>
<td><em>pa:kunila ivicai</em></td>
<td><em>ena aḷai kappāṭukiratu</em></td>
</tr>
<tr>
<td>2. <em>paruppoo.ruḷ u:ṭakam onrin veppakkarī veppam paravum vi:cal murai</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'heat energy transmitted 'Radiation'</td>
<td>known as</td>
<td></td>
</tr>
<tr>
<td>from one place to another without the aid of any material medium'</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.3.2.12 Visualization

Visuals are used to reveal the content of verbal message related scientific objects or concepts. The visuals that are found in science discourse are graphs, tables, diagrams, charts, figures and other illustrative materials. They help the readers of science text to clearly interpret the science concepts presented. They also function as paralinguistic features in science writings.

Visualization is the techniques or act of introducing visuals appropriate to the description, figuring info discourse. This act functions as an aid to display visually scientific concepts.

4.3.3 Functional key verbs in Tamil science discourse

Tamil science discourse reflects organisation of the use of language in terms of rhetorical function and rhetorical structure. Rhetorical function is the purpose and the communicative act which underlie the production of scientific information through language. The rhetorical
functions governing the science discourse are classified as definition, description, instruction, classification and other similar acts.

Rhetorical structure is the organisation of the utterances of science discourse and this organisation is manifested through placement and organisation of paragraph, choice and manipulation of construction, choice and creation of technical terms in construction.

Rhetorical function which underlies the sentences and paragraph of science discourse are overtly revealed by the choice of verbs found in the sentences and paragraph. These verbs are called as functional key verbs. By identifying these functional key words, it is possible to assess the nature of the paragraphs with reference to the underlying rhetorical functions. Consider the following paragraph.

'Polaroids have nowadays replaced nicols for polarising and analysing purposes. Polaroids have wide applications in day to day life. They are used as sunglasses. They are fitted in the head lamps of motor cars and in wind screens to avoid glare. Polaroids are also used in stereoscopic motion pictures to give three dimensional views. Aerial pictures may be taken from slightly different angles and when viewed through polaroids give a better perception depth'.

This paragraph contains four sentences. These sentences end up with verbs. By looking at the type verbs used at the end of the sentences of this paragraph, one could judge that this paragraph talks about the use of polaroids. The following table reveals the sentences final verbs and rhetorical function those verbs show.

<table>
<thead>
<tr>
<th>Sentence</th>
<th>Final verb</th>
<th>Rhetorical function</th>
</tr>
</thead>
<tbody>
<tr>
<td>S_1</td>
<td>'are used'</td>
<td>use</td>
</tr>
<tr>
<td>S_2</td>
<td>'are used'</td>
<td>use</td>
</tr>
<tr>
<td>S_3</td>
<td>'are used'</td>
<td>use</td>
</tr>
</tbody>
</table>
By observing the above table and the kind of verbs used in the paragraph, one could say that this paragraph talks about the use of polaroids.

Tamil being the verb final language, by observing the final verb of the sentence, one could observe the rhetorical function for the reflection of which the verbs are used. Some of the verbs and the rhetorical functions correlated with them are as follows:

<table>
<thead>
<tr>
<th>Rhetorical function</th>
<th>Sentence final verb</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Description</td>
<td>a:kum 'it is'</td>
</tr>
<tr>
<td></td>
<td>celkinrana 'it moves'</td>
</tr>
<tr>
<td></td>
<td>tēvaillai 'not necessary'</td>
</tr>
<tr>
<td>2. Description of the use</td>
<td>payanpatukinrana 'are used'</td>
</tr>
<tr>
<td></td>
<td>vilaihinrana 'are used'</td>
</tr>
<tr>
<td></td>
<td>payanpatuttappatinrana 'are used'</td>
</tr>
<tr>
<td>3. Visualization</td>
<td>ka:nka 'to see'</td>
</tr>
<tr>
<td></td>
<td>ka:tükiratu 'it shows'</td>
</tr>
<tr>
<td></td>
<td>ka:nalal 'it may be seen'</td>
</tr>
</tbody>
</table>
Here some of the sentences of science discourse are given to show that sentence final verbs reflect the rhetorical function of the sentences concerned.

Description 1:
rețiyo:c caykaikal (rețiyo:c ceytikal) oliyin ticaivekattil celkinrana.
'radio signals travel with the velocity of lights'

Naming 2:
tulaikalai ottatirum po\ntukal enpar
'the holes are called resonance cavities'

Visualization 3:
alaivuc curril minno:ttam mellamella kuraivataip paṭam.
A graph showing how current slowly decreases in an oscillatory circuit is given in Fig. 4-41(b).

Direction 4:

'It is instructive to compare the above action of a valve oscillator with the oscillations of a swing which are maintained by the person swinging on it'.

Attestation 5:
ko:parnikas katiravamayak ko:tpa:ttai etutturaitta:r

'Kopernicus, propounded the helio-centric theory'

Classification 6:
alai iyakkattai iru perum pirivukala:kap pirikkala:m

'the wave motion can be broadly divided into two types'

Assumptions 7:
ABCDNKLM enra tinkanacaturam onraik karutuo:m

'let us consider a solid cube ABCDNK.'
4.3.4 Problems in discourse translation

Translation related to science may involve translation of technical terms and discourse. Technical term translation involves searching for equivalent words in the target language for the source language technical term which refer to scientific objects, events, process etc.

Many problems arise when technical terms are translated. The cause for the problems behind the translation of technical terms are non availability of perfect equivalents, individuality in adopting the strategies of translation, preservation of the genius of the target language, the decision regarding what has to be transliterated and translated etc., Due to the adoption of different strategies of translation namely paraphrasing, use of archaic word with renewal of meaning or semantic extension, adoption of non frequent suffixes and creating technical words in productive way are some of the strategies employed. Due to this, variants in technical terms in Tamil are produced. So some measures where taken to standardize the technical terms.

In the same way of problem arise when science discourses of the source language are translated into target
language Tamil. Ultimately the problems arise due to the way in which rhetorical technique are adopted during translation process. When coming to the translation of sentences of science discourse and their translation one could find the source language sentence and target language equivalent sentence manifest variations due to the difference in order, focus, types of sentence and length of the sentences.

For instance source language sentences with subject, verb and adjunct pattern are converted into subject, adjunct and verb pattern in the target language.

Example:
Source language: Radio waves of wavelengths 10 to 1 metres are used in television
Target language: 10mi mutal 1 mi varai alaini:jamuṭaiya reṭiyō: alaikaḷ to:laikka:ṭciyil payanpaṭkinrana.

In the above sentence the adjunct 'in television' occurs finally in the source language, whereas, it occurs in the middle in the target language Tamil. Moreover the passive verb 'are used' is translated as [payanpaṭu kinrana] 'getting used instead of [payanpaṭuttap patukinrana].

During translation of sentences, focus difference also occurs.
Example:
Source language: 'x-rays do not produce heat' ....
Target language: porrutkal mi:tu x-katirkal patum po:tu avai veppamaṭaivatu illai.

The above translation is a miss translation due to focus difference. The translated form if rendered in English will be read as follows.

"When X-rays fall on an object, that object will not get heated". The actual translation should have been "X-katirkal veppattai veliyituvatillai".

During translation, source language complex sentences are cut into simple sentence in the target language Tamil.

Example:
Source language: It consists of a metal rod with a pointed end fixed on top of the building, the other end of the rod being connected to a ..... 
Target language: itu oru ulo:kat tāṇṭa:1 a:ṇatu.

It is also observed that certain words carrying
specific information are omitted and the information is made general during the process of translating source language sentences into target language sentences.

Example:

Copper plate, scanning, synchronization, wet earth etc.

Example:

Source language: ..... the other end of the rod being connected to a large copper plate, buried deep in wet earth .....,

Target language: Kattatattin veliye pu:miyil a:lap putainta takattutan minninappu perukinratu.

Source language: This image is then converted into electrical oscillations by a process called scanning.

Target language: Pimpam telivisan Kemara:vin tiraiyil perappatukinratu.

Source language: The exploring spot in television camera and the reproducing spot in the picture tube are kept exactly in step by a suitable technique called synchronisation.
In the above discourses some words like 'copper plate, wet earth, scanning and synchronization' are missing.

In general variation occurs while discourses and sentences of discourses are translated. But so far no methodology has been evolved to standardize science discourse production and translation in Tamil.