

# Quantitative Analysis of Kinetic Structure in a High School Biology Lecture

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## I. INTRODUCTION

Verbal interactions account for a large proportion of classroom behavior and most information is presented through teacher's verbal communication. Also, the learning process is serial with only a limited amount of information assimilated within a given unit of time. Therefore, there is strong necessity of considering teacher verbal behavior in the complete analysis of teaching for effective and efficient instruction and the serial order of presentation of verbal information should be considered in the learning process and in the organizing instructional structure.

Although the concept of structure as related to the organization of knowledge in the curriculum has gained wide currency in educational theory, the organization of teacher communicated subject matter as it occurs naturally in the classroom has received little systematic attention by researchers. We have few educational theories sufficiently general in scope with precisely defined concepts to permit their careful evaluation in the natural setting of the classroom. Moreover,

the lack of carefully defined principles and systems of analysis precludes effective teacher training through self-analysis.

The pioneering investigation has been done by O. Roger Anderson in America. "Structure in Teaching" (Anderson, 1969) was one of the first attempts to formulate a theory of teaching in which the concept of structure played a central role. Anderson developed "Theory of Kinetic Structure" and provided a rationale and a methodology of structuring verbal communication in teaching. He used a quantitative method for determining and fixing the degree of structure that a communication may possess.

According to Anderson(1971), the structure of the subject matter is the continuity of ideas from one discourse unit to the next and the pattern of organization of themes and arousal points in the communication sequence that mediates enhanced cognitive encoding of information. Anderson (1969) predicted that a communication having high structure would facilitate greater knowledge acquisition than a presentation with low structure. Many studies (Anderson & Lee, 1975; Browne & Anderson, 1974; Rawwas, 1985; Trindade, 1972) investigated the effects of varying the kinetic structure of materials on students acquisition of science content and found that student co-

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ment achievement was directly related to lesson kinetic structure.

In this study, the theory and the methods developed by Anderson were adapted to Korean. The purpose of this paper is to present the theory of structure in teacher communicated content and the related theory based system of analysis applicable to classroom as well as controlled laboratory studies.

## II. THEORY

### Theoretical assumptions

Anderson's theory of kinetic structure is built upon certain biological and psychological principles. The following are its basic assumptions:

- ① The natural environment favored to the evolution of organisms possessing receptors and nerve networks sensitive to periodic stimuli.
- ② During human ontogeny, visual scanning of the environment produces a succession of images on the retina of the eye wherein each image contains some elements in common with contiguous images. These experiences predispose the organism to anticipate common properties or shared elements in successive stimuli.
- ③ Language and thought are products of these genetic influences. They are both in part serial processes wherein contiguous units hold elements in common.
- ④ Acquisition of verbal material is enhanced when continuous verbal units (statements) in a communication contain identical verbal elements or hold other properties in common.

There are two basic assumptions to the concept of structure in teaching: ① teaching is a serial phenomenon, and ② it is partially periodic. Classroom observation of teaching suggests that it is sequential and that certain activities and verbal utterances representing ideas recur periodically. We can find the physiological and psychological origins of verbal periodicity in human communications from the above assump-

tions.

### Definition of kinetic structure

The concept of structure in teaching is called kinetic structure. Kinetic structure in verbal communication is the linking together of statements by words they hold in common, and the serial order of the statements. Stated in another way, kinetic structure is the continuity of ideas within contiguous statements in a stream of discourse. The greater the continuity or connectedness of ideas within consecutive pairs of discourse units, the greater will be the degree of kinetic structure.

In performing structural analysis, the stream of discourse is broken into individual statements called discourse units. A discourse unit is fundamentally a sentence-- a statement containing a subject and a predicate. Discourse units contain words called verbal elements. A verbal element is any technical word or any its synonyms within a substantive field. We can state for simplicity that verbal elements are words representing substantive ideas.

With these definition of discourse unit and verbal element in mind, we can define degree of kinetic structure somewhat more precisely. The quantitative degree of kinetic structure is the amount of shared verbal elements, that is, the number of common or matched verbal elements in consecutive pairs of discourse units and the distribution of arousal points in a communication as assessed by graph called kinetogram.

### Commonality and progression

Commonality means the condition of sharing the same elements. Thus, commonality in pairs of discourse units means holding one or more verbal elements in common. The larger number of verbal elements shared by a pair of discourse units, the greater commonality. Also, commonality is an expression of periodicity within a verbal communication since it concerns the repetition or reappearance of verbal elements within a series of discourse units. A quantitative

methods (fundamental coefficient of structure,  $B_1$ ) for assessing the commonality is explained in the section of methodology.

A complementary concept to commonality is progression. Progression is defined as the rate of appearance of new or unmatched verbal elements in a communication. Whereas commonality concerns the amount or matching of verbal elements in pairs of discourse units, progression means the amount of unmatching and number of new verbal elements in discourse unit pairs. The formula for progression is  $P=1-B_1$ . Thus, when commonality is high ( $B_1$  near 1.0), progression must be low since  $P$  will approach zero. A more useful formula for assessing the rate of appearance of new verbal elements in a sequence of discourse units is progression density coefficient,  $D_p$ . It is explained in the section of methodology.

### Learning and kinetic structure of communication

According to Anderson (1971), learning is in part a function of response contiguity, a process whereby the repetitive arousal or the close temporal occurrence of responses in a sequence occasions associations among the responses. These associations are formed largely through the mediation of sensory and nerve organs acquired during phylogeny and stimulated during ontogeny to readily assimilate repetitive or temporally contiguous stimuli.

Since verbal responses are often acquired through verbal stimuli, there is a complementary principles for the organization of verbal communications: Acquisition of verbal responses will be enhanced when they are evoked by a communication wherein contiguous stimulus units hold elements in common. That is, the strength and the serial association of responses aroused by a communication are directly related to the commonality among discourse units in the communication. Therefore, effective communication requires that contiguous statements contain some verbal elements in common, that is, high degree of kinetic structure.

Obviously, maximum kinetic structure occurs when a pair of consecutive discourse units contain the same or nearly the same group of verbal elements. In such a case, structure is maximum since reiteration of the substantive ideas reinforces them, thereby producing a strong link at that point in the chain of verbal utterances. Maximum effectiveness of communication occurs when the same statement is reiterated, producing a stamping in or practice effect in verbal learning.

Although repetition of this sort is effective for communicating a limited amount of verbal content during brief periods of time, it is not efficient in maintaining pupil attention and communicating larger masses of content where new thoughts must be introduced as the communication unfolds. For physiological and psychological reasons, too much highly structured discourse unit pairs will depress knowledge acquisition. It is a well established neurophysiological principles that excessive repetition of the same stimulus will lead to a decrement or temporary annihilation of sensory responding to that stimulus. Thus, we might expect some loss in cognitive encoding of verbal content since boredom (cognitive adaptation) will result in a shift of attention from the communication. However, after a period of rest, sensitivity to the stimulus will return. One way of maintaining arousal during repetitive stimulation is occasionally to shift the kind of stimulus. A shift in kind of stimulation is of course an example of progression. By continuously introducing new verbal elements, the organism remains alert during verbal stimulation. Thus, progression, when properly balanced with commonality, maintains arousal and helps keep the organism entrained to the stimulus source. Therefore, some progression is obviously necessary and desirable to achieve optimal learning of verbal content and to introduce new verbal content.

Likewise too excessive progression, too little structure (insufficient continuity of ideas), will also depress knowledge acquisition. Excessive cognitive fatigue will be produced when the learner is required to supply most of the linking ideas between statements in a communication.

The thrust of this discussion is that there must be a balance between commonality and progression in a communication. Anderson(1971) explains that effective and efficient classroom communication requires the proper mixture of commonality and progression. From a theoretical viewpoint, commonality is necessary for effective communication. Thus some commonality assures that the organism will be able to follow the communication and that his requirement for periodicity in stimulation will be satisfied. In order for a communication to be efficient, however, some progression is required. New information should appear continuously in order to introduce the learner to additional substantive content and also as a way of avoiding habituation and maintaining a reasonable state of cognitive arousal.

In teaching, an optimal mixture of commonality and progression will vary with the kind of material being presented and the psychological characteristics of the pupils. At some points the teacher may choose to conserve commonality by presenting the same idea in many different ways. At other points, where the material is easily encoded, the amount of progression may be increased to arouse the pupils' attention and lead them into new content areas with the greatest possible efficiency. Careful studies will be required to elucidate these relationships.

### III. METHODOLOGY

A communication was recorded on tape from a high school biology lecture. This communication was addressed to the topic of human digestive system and lasted for 50 minutes. The high school is located on the outskirts of Seoul and the teacher had taught biology for 4.5 years. The methodology of kinetic structure analysis of the communication is as follows.

#### 1. Recording a communication and preparing a transcript for numerical analysis

A cassette tape recorder was used to obtain a complete record of teacher verbal behavior. The audio record was transcribed as a written protocol. Both teacher and pupil statements were transcribed although in this study only the teacher statements were analyzed.

##### 1) Identifying discourse units

After the stream of discourse was transcribed, the written record was broken into discourse units. A set of rules for identification of discourse units is summarized as follows. Anderson's (1971) rules were adapted to Korean communication by the author.

- ① The basic unit: The basic unit of discourse is a single full sentence which expresses complete thought and contains a subject and a predicate.
- ② Incomplete utterance: (a) A word, phrase, or other grammatically incomplete utterance is combined with the preceding sentence if it is stated by the same speaker. (b) If incomplete utterance is preceded by the statement of another speaker but followed by a statement of the same speaker, it is combined with the following statement. (c) When an incomplete utterance occurs between statements of other speakers, it is accepted as a single discourse unit.
- ③ Complex sentence: (a) A sentence embedded within a subsuming sentence is retained within the subsuming statement as a part of a single discourse unit. (b) Two sentences connected by a connective ending are not separated into two discourse units.
- ④ Sentences beginning with a connective adverb are separated at the connective adverb to form individual discourse units. But when preceded by another statement by the same speaker, the sentence beginning with a because is combined with the preceding statement unless a speaker tends to run many statements together.

These rules were developed as a result of practical experience in coding transcripts. The purpose of the rules is to allow identification of meaningful small units of discourse with a minimum amount of subjective judgement. When unique situations arise beyond the scope of these rules, the intent of the first rule should

be applied, that is, to render the communication into the smallest possible discourse units where each approximates a grammatically complete thought.

When preparing the transcript, discourse units are single spaced with a double space between units and numbered consecutively, Pupil statements are preceded by dashes to set them apart from teacher statements.

## 2) Identifying verbal elements

After discourse units were identified in the communication, the verbal elements were identified and coded for each discourse unit. The verbal elements are simple word or complex word. The following criteria are to be used in identifying verbal elements

- ① Any technical word or term appearing in a standard dictionary, encyclopedia, or handbook, or constituting part of the recognized terminology of the subject matter being communicated, is a verbal element.
- ② Any word or term used as a synonym for one of the above elements is coded as equivalent to that element.
- ③ Any word serving as a surrogate for a technical term and occurring with high frequency is selected as a verbal element even if it fails to meet the criteria stated in rules ① and ②.
- ④ Any term containing two or more words (complex word) denoting an object, class of objects, or event is listed as a single verbal element. Care should be taken to keep words separated whenever possible. In most case (when in doubt) it is better to separate the compound word terms than to group them together.
- ⑤ The indeclinable adjectives are separated from the indeclinable words (nouns) they modify to form separate verbal elements.
- ⑥ Verbs should be coded infrequently as they usually serve more as a sentence structure element rather than a connective element in extended discourse. Hence only action, technical verbs are coded. If in doubt, do not code the verb.
- ⑦ Usually verbal elements are nouns, indeclinable

adjectives, verbs listing in order of decreasing importance. In general, we are seeking to describe the connected discourse for the central technical ideas being communicated. Thus, choose words as verbal elements that meet that intent.

## 3) Coding verbal elements in a transcript

The transcript was coded as follows.

- ① Each discourse unit is examined to determine the presence of verbal elements. A list of verbal elements is compiled containing the code number and name of each verbal elements. Once a code number has been assigned to a verbal element, it is used to represent that element each time a discourse unit appears containing the element. The code numbers of all verbal elements are entered in the right-hand margin of the transcript opposite the discourse unit where they appear.
- ② Pronouns referring to noun elements in preceding discourse units are assigned the same code number as the elements they represent. If a pronoun clearly refers to a group of elements in a preceding discourse unit, the code numbers of all the referent elements are assigned to the pronoun.
- ③ Each verbal element is coded only once for a given discourse unit, irrespective of the number of times it appears in the unit.
- ④ When a pronoun and noun taken together represent a two-word verbal element, the pair is assigned the code number of the compound verbal element.

## 2. Computing coefficients of structure

The coefficients of structure were computed by the matching elements method (Anderson, 1971). A computer program is available from the author to compute some of coefficients and tabulate their distribution in the whole communication being analyzed.

### 1) Fundamental coefficient ( $B_1$ )

The fundamental coefficient of structure is used to obtain a measure of commonality between successive pairs of discourse units, it is defined as follows.

$$B_1 = \frac{n_1}{n_0 + n_1}$$

where  $n_1$  is the number of matched and  $n_0$  the number of unmatched elements in a unit pair.

### 2) Weighted coefficient ( $B_2$ )

The weighted coefficient of structure is a modified fundamental coefficient. It includes a potency factor in addition to the terms used to compute commonality. The potency factor is an estimate of the saliency of unmatched elements in a pair of discourse units. The weighted coefficient is computed as follows.

$$B_2 = 1 - \left[ \frac{n_0}{n_0 + n_1} \cdot \left( \frac{F' + F''}{\Sigma f} \right)^{1/2} \right]$$

where  $F'$  and  $F''$  are the total frequency of the highest frequency unmatched element in the first and second unit respectively.  $\Sigma f$  is the total frequency of all elements in the total communication.

### 3) Mean progression density coefficient ( $\bar{D}_s$ )

The mean progression density coefficient is used to quantitatively assess the rate of appearance of new verbal elements in a span (new with reference to that span regardless of the element appeared in a previous span) and the amount of commonality conserved as the new elements appear. The formula for the mean progression density coefficient is the following.

$$\bar{D}_s = \frac{\sum_{i=s}^{s'} [(1-B_1)_i \cdot n_i]}{S}$$

The limits of the span are  $s$  and  $s'$  which stand for the first and last discourse units in the span.  $S$  is the span length and  $n_i$  is the number of new verbal elements introduced in the second discourse unit  $i$ .

Mean progression density is often reported in combination with another coefficient called the new activity coefficient (NAC) which is the average number of new elements per unit in a given span.

$$NAC = \frac{\sum_{i=s}^{s'} n_i}{S}$$

### 3. Plotting Kinetograms

A kinetogram is a graph whose abscissa is divided into units representing discourse units with limits of 0 to  $N$ . Where  $N$  is the maximum number of discourse units to be analyzed. The ordinate represents  $B_2$  values and divided into 10 unit intervals from 0 to 1.0. A  $B_2$  value is computed for each discourse unit and plotted as a line graph to yield a kinetogram.

Kinetogram is used for two purposes: ① to summarize the structure of a communication; ② to aid in the analysis of organizational patterns in a communication.

### 4. Primary and secondary spans

A communication can be analyzed into sequences in terms of continuities and discontinuities in verbal content. These identified sequences are called secondary spans. Secondary span should be at least four discourse units long. The method of identifying secondary spans involves simultaneous examination of a code summary sheet, displaying all of the code numbers assigned to each discourse unit of the lesson, and of the corresponding kinetogram trace. The transcript of the discourse should also be examined to confirm the logic of span identification. Anderson's (1971) rules for the identification of kinetogram spans were used without any modification.

The secondary spans are sometimes grouped together into longer sequences called primary spans. Primary spans are identified in much the same way as secondary spans except that the activity of the dominant element is often much less concentrated. Therefore, one must be alert to find discontinuous yet persistent activity of one or more elements as evidence for primary spans. A primary span encloses two or more secondary spans and begins with the first subsumed secondary span and terminates at the end of the last subsumed secondary spans.

## IV. ANALYSIS OF KINETIC STRUCTURE

This verbal communication was recorded from a high school biology class (10th grade) and was on the topic of human digestive system. It consists of 316 discourse units and has total 261 verbal elements. This communication contains 37 secondary spans, which are grouped into 6 primary spans (see Table 1)

Table 1. Descriptive Data of Communication

Total Number of Discourse Units 316	Verbal Elements Total Frequency 261
Mean Fundamental Coefficient 0.26	Mean Weighted Coefficient 0.88
Number of Primary Spans 6	Number of Secondary Spans 37

Table 2. Distribution of Fundamental Coefficients and Weighted Coefficients

Interval	Proportion of $B_1$	Proportion of $B_2$
0.00-0.10	0.47	0.00
-0.20	0.01	0.00
-0.30	0.09	0.00
-0.40	0.09	0.00
-0.50	0.07	0.00
-0.60	0.13	0.00
-0.70	0.07	0.00
-0.80	0.00	0.16
-0.90	0.04	0.37
-0.99	0.00	0.44
1.0	0.03	0.03

The grand mean fundamental coefficient of the whole communication is  $\bar{B}_1=0.26$  and 57% of  $B_1$  values are in the interval from 0.00 to 0.30. This  $B_1$  value is quite low compared to those analyzed in the American science classroom communications ranged from 0.29 to 0.44 (Anderson, 1971). Anderson categorized communications into low structure (below 0.30) communication and high structure (0.35-0.45) communication according to their mean fundamental coeffi-

cients. Thus, this communication has low structure. The low commonality will require the learner to supply linking ideas between statements and thus some cognitive fatigue will be produced. The grand mean weighted coefficient is  $\bar{B}_2=0.88$  and 84% of  $B_2$  values are above 0.90 (see Table 1 and 2).

Figure 1 shows the kinetogram of the communication and Table 3 and 4 present the kinetogram summary data of the primary and the secondary spans. The first primary span (D.U. 1-10) contains the topic of digestion in the mouth and is dominated by the verbal elements of mouth [184:3, 0.38] and saliva [216:3, 0.75], whose coefficients of specificity are 0.38 and 0.75 respectively. Specificity is the ratio of the verbal element frequency in a span to its total frequency in the whole communication. The mean fundamental coefficient for this primary span is  $\bar{B}_1=0.30$  and the mean weighted coefficient is  $\bar{B}_2=0.91$ . This span has high mean progression density ( $\bar{D}_3=1.73$  with  $NAC=2.00$ ). Thus, this suggests that new information is being highly introduced to the students at the average rate of two verbal elements per discourse unit. This primary span is said to be moderately high structure. Two secondary spans are contained in this primary span. The first secondary span (D.U. 1-6) has high mean fundamental coefficient ( $\bar{B}_1=0.37$ ) and very high mean progression density ( $\bar{D}_2=1.80$ ) with high  $NAC=2.00$ , which is high structure. These values and pulsed decay series in the kinetogram (see Figure 1) suggest that the outset of the communication is entering into a new span with a different topic.

Table 3. Kinetogram Summary of Primary Spans

Spans	Limits	Mean $B_1$	Mean $B_2$	Mean $D_3$	Mean $NAC$	Verbal Elements
1	1-10	0.30	0.91	1.73	2.00	saliva(216:3, 0.75)*
2	11-66	0.30	0.89	0.79	0.96	stomach(168:11, 0.61)
3	57-169	0.22	0.88	0.92	1.04	degradation(85:15, 0.58)
4	170-182	0.22	0.86	1.01	1.23	decay(81:5, 0.71)
5	183-278	0.30	0.88	0.78	0.96	absorption(259:34, 0.79)
6	279-316	0.22	0.88	1.19	1.37	liver(6:13, 0.57)
Grand Mean		0.26	0.88	1.07	1.26	

\* verbal element (code of verbal element:activity, specificity)

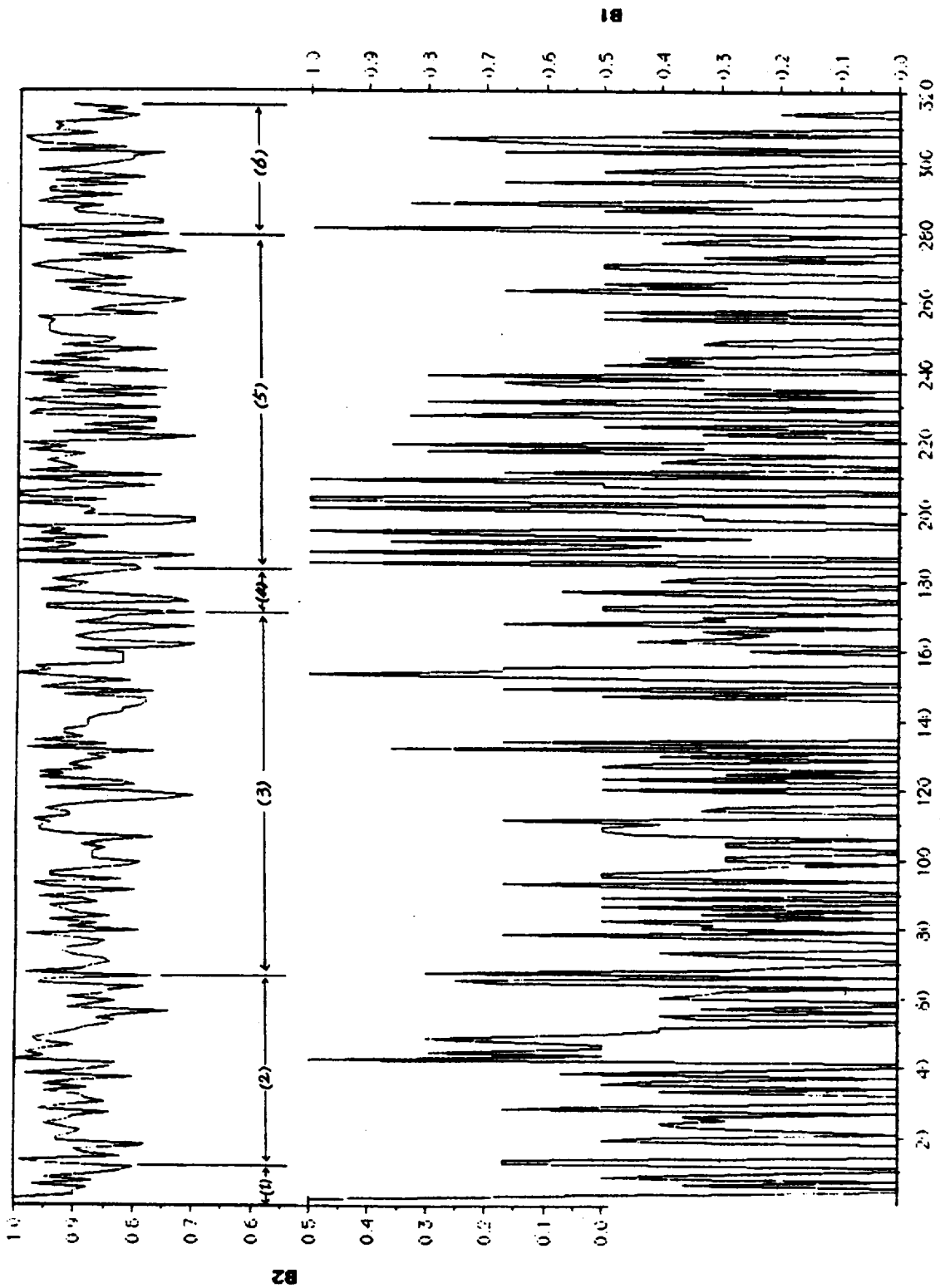


Figure 1. Kinetogram of Transcript



Table 4. Kinetogram Summary of Secondary Spans

Spans Limits	Mean B <sub>1</sub>	Mean B <sub>2</sub>	Mean D <sub>1</sub>	Mean NAC	Verbal Elements
1 1-6	0.37	0.93	1.80	2.00	mouth(184.3, 0.38)*
2 7-10	0.21	0.88	1.13	1.50	saliva(216.3, 0.75)
3 11-16	0.22	0.89	1.72	1.83	stomach(168.3, 0.17)
4 17-27	0.23	0.88	1.29	1.55	gastrin(4.5, 0.83)
5 28-36	0.26	0.91	1.06	1.33	HC (160.4, 0.50)
6 37-40	0.21	0.88	1.45	2.00	denaturation(76.2, 1.00)
7 41-55	0.45	0.91	0.42	0.73	protein(40.6, 0.40)
8 56-66	0.25	0.86	0.80	0.91	stomach wall(169.6, 0.60)
9 67-70	0.32	0.89	2.31	2.75	duodenum(140.3, 0.38)
10 71-80	0.18	0.89	2.04	2.30	secretin(112.5, 1.00)
11 81-87	0.23	0.89	1.07	1.14	neutralize(206.3, 0.75)
12 88-93	0.26	0.91	1.02	1.33	amylase(146.3, 1.00)
13 94-102	0.24	0.87	0.65	1.00	lipase(134.5, 0.63)
14 103-118	0.23	0.88	1.23	1.44	trypsin(228.5, 1.00)
15 119-143	0.16	0.88	0.90	0.96	bile(144.7, 0.64)
15 144-161	0.24	0.86	0.96	1.06	maltose(58.6, 0.67)
17 162-165	0.24	0.84	1.30	1.75	degradation(85.4, 0.15)
18 166-169	0.32	0.82	1.43	1.50	absorption(259.3, 0.07)
19 170-174	0.27	0.83	1.00	1.20	absorption(259.3, 0.07)
20 175-182	0.20	0.88	0.90	1.13	decay(81.5, 0.71)
21 183-186	0.25	0.85	0.50	0.50	kettle(202.2, 1.00)
22 187-197	0.49	0.88	0.33	0.55	absorption(259.8, 0.19)
23 198-208	0.42	0.89	0.65	0.82	villi(174.3, 0.50)
24 209-221	0.34	0.90	0.98	1.15	diffusion(255.4, 0.67)
25 222-228	0.31	0.87	0.81	1.00	absorption(259.5, 0.12)
26 229-232	0.40	0.91	0.36	0.50	movement(166.3, 1.00)
27 233-244	0.33	0.88	1.17	1.50	capillary(63.6, 0.60)
28 245-256	0.10	0.89	1.27	1.42	vitamin D(92.2, 1.00)
29 257-266	0.23	0.84	0.89	1.10	liver(bc5, 0.22)
30 267-271	0.26	0.92	1.14	1.40	lymphatic duct(54.4, 0.80)
31 272-278	0.15	0.84	1.65	2.00	heart(139.3, 0.33)
32 279-282	0.38	0.87	0.75	0.75	liver(6.3, 0.13)
33 283-288	0.26	0.87	0.94	1.33	ammonia(149.4, 1.00)
34 289-295	0.13	0.89	1.29	1.29	alcohol(148.2, 0.40)
35 296-302	0.15	0.85	1.52	2.00	nicotine(38.3, 1.00)
36 303-312	0.30	0.92	0.99	1.20	blood-sugar level(249.5, 0.83)
37 313-316	0.05	0.85	1.80	2.00	bile(144.2, 0.18)
Grand Mean	0.26	0.88	1.12	1.35	

\*verbal element (code of verbal element:activity, specificity)

The second primary span (D.U. 11-66) on the stomach is dominated by the verbal elements of protein (40:10, 0.67), digestion (118:9, 0.29), stomach (168:11, 0.61), and stomach wall (169:9, 0.90). This span has low mean fundamental coefficient ( $\bar{B}_1=0.30$ ) and moderate mean progression density ( $\bar{D}_s=0.79$ ) with a value of NAC=0.96. The mean weighted coefficient of this span is  $\bar{B}_2=0.89$ , which is close to that of the total communication. Thus, this primary span shows moderately high structure. There are six secondary spans in this primary spans. The 7th secondary span (D.U. 41-55) has very high mean fundamental coefficient ( $\bar{B}_1=0.45$ ) and low mean progression density ( $\bar{D}_s=0.42$ ) with NAC=0.73. Thus this secondary span has high structure. High commonality and low progression will facilitate the acquisition of the verbal communication which is dominated by the verbal elements of protein (40:6, 0.40) and digestion (118:6, 0.19). This secondary span has pulsed decay series.

The third primary span (D.U. 67-169) is presenting the content about the small intestine. Dominated verbal elements of this span are maltose (58:8, 0.89), degradation (85:15, 0.58), digestion (118:12, 0.39), lipase (134:8, 1.00), bile salts (144:8, 0.73) and fat (206:8, 0.89). This span has quite low mean fundamental coefficient ( $\bar{B}_1=0.22$ ) and high mean progression density ( $\bar{D}_s=0.92$ ) with NAC=1.04. Its mean weighted coefficient is  $\bar{B}_2=0.88$ . Thus, this span has low structure. This primary span consists of ten secondary spans which have moderate to low structures.

The fourth primary span (D.U. 170-182) is on the topic of the large intestine and is dominated by the verbal elements of smell (31:4, 0.80) and decay (81:5, 0.71). This span has low structure with low mean fundamental coefficient ( $\bar{B}_1=0.22$ ) and high mean progression density ( $\bar{D}_s=1.01$  with NAC=1.23). The mean weighted coefficient is  $\bar{B}_2=0.86$ . This primary span contains two secondary spans (D.U. 170-174, D.U. 175-185), both of which have low structure.

The fifth primary span (D.U. 183-278) on the absorption of nutrients is dominated by the verbal elements of capillary (63:10, 1.00), lacteal (150:8, 1.00)

and absorption (259:34, 0.79). The mean fundamental coefficient is  $\bar{B}_1=0.30$  and the mean weighted coefficient is  $\bar{B}_2=0.88$ . This span has moderate mean progression density ( $\bar{D}_s=0.78$ ) with  $NAC=0.96$ . Thus this primary span has moderately high structure. This span has lots of pulsed series, which suggest many divergent topics are communicated. There are eleven secondary spans in this primary span. The 22nd, the 23rd, and the 26th secondary spans have high structures, whose mean fundamental coefficients are  $\bar{B}_1=0.49$ , 0.42, and 0.40 respectively.

The last primary span (D.U. 279-316) is discussing about the liver and is dominated by the verbal elements of liver (6:13, 0.57), degradation (85:6, 0.23), control (198:5, 1.00), synthesis (243:5, 1.00), and blood-sugar level (249:5, 0.83). This span has low mean fundamental coefficient ( $\bar{B}_1=0.22$ ) and high mean progression density ( $\bar{D}_s=1.19$ ) with  $NAC=1.37$ . The mean weighted coefficient is  $\bar{B}_2=0.88$ . Thus this span has low structure. This primary span consists of six secondary spans. The 32nd secondary span (D.U. 279-282) shows high structure with high mean fundamental coefficient ( $\bar{B}_1=0.38$ ) and moderate mean progression density ( $\bar{D}_s=0.75$ ). The 36th span (D.U. 303-312) has moderately high structure with  $\bar{B}_1=0.30$ ,  $\bar{B}_2=0.92$ , and  $\bar{D}_s=0.99$ . This secondary span has pulsed gain series.

In general this verbal communication has moderate to low structure and high progression. Each discourse unit introduces new verbal elements at the rate of over one element. Low commonality and high progression will give listeners difficulties in the acquisition of knowledge. A reasonable balance between commonality and progression is needed.

## V. CONCLUSION

This preliminary study suggests that there is an understandable organization in the teacher communicated content. The results of this study demonstrate that the system of analysis is workable and that kinetograms provide a convenient tool for analysis and dis-

play of the organization of teacher communicated content.

The quantitative methods of analysis described here provide a reliable and systematic method for the identification and structural classification of discourse spans in a communication. These are applicable to interaction analysis of discourse among several speakers as well as to the monologue analyses.

Further studies are needed to ascertain the effect of varying kinetic structure on the acquisition of science knowledge. Psychological reinforcement theory predicts that knowledge acquisition will decline concurrently with a decrease in the kinetic structure.

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## 〈요약〉

# 고등학교 생물 강의에서의 역동적 구조의 정량적 분석

김 영 수

학교 교실에서의 수업 활동 중 가장 주된 활동은 언어적 의사소통이며 대부분의 지식 전달이 교사의 언어 활동을 통해 이루어지고 있다. 그리고 교사의 언어적 의사소통의 순서와 구조는 효과적이고 효율적인 학습에 중요한 의미를 가지므로 이를 조직적으로 분석 평가할 필요가 있다.

따라서, 이 연구는 교실에서의 교사 언어 행동의 구조를 분석·연구할 수 있는 방법론적 기초를 마련하고자 Anderson의 역동적 구조 이론(Theory of Kinetic Structure)을 소개하고, 그의 정량적 분석 방법을 한국어에 적용할 수 있도록 수정하였으며, 교사의 실제 강의 내용을 분석하였다. 분석에 사용한 자료는 50분 동안 진행된 고등학교 1학년 생물 강의를 녹음한 것으로 소화에 관한 내용이었다.

강의 내용에서 역동적 구조의 정량적 분석 결과는 다음과 같다.

강의는 316개의 담화단위(discourse units)로 구성되었으며, 261개의 어소(verbal elements)가 동정되었다. 전체 강의에서 37개의 secondary span이 동정되었고 이는 6개의 primary span으로 구분되었다. 전체 강의에 대한 평균 기본계수(mean fundamental coefficient,  $\bar{B}_1$ )는 0.26으로 낮은 수준의 연관도(commonality)를 보였으며, 평균 가중 기본계수(mean weighted coefficient,  $\bar{B}_2$ )의 값은 0.88이었다. 전체적으로 이 강의는 중 내지 하 구조(moderate to low structure)를 갖고 있으며, 높은 진행도(high progression,  $\bar{D}_3 = 1.07$ )를 보였다.