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ENGINEERING STUDENTS

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Tämän tutkimuksen tarkoituksena on selvittää, kuinka hyvin suomalaiset tekniikan opiskelijat ymmärtävät oman alansa englanninkielisiä tekstejä. Tutkimusaineisto koostuu Tampereen teknillisen korkeakoulun opiskelijoiden englanninkielisten tekniikan alan tekstien tiivistelmistä. Tiivistelmiä tutkimalla ja analysoimalla pyritään selvittämään, kuinka paljon niistä löytyy alkuperäisten tekstien keskeisiä asioita, ja onko niissä käytetty rakenne samanlainen kuin alkuperäisissä teksteissä. Tutkimus on laadullinen ja tapaustutkimuksen kaltainen, mikä johtuu muun muassa aineiston pienestä määrästä.

Alkuperäisistä teksteistä valittiin pääkohdat, jotka perustuvat kahden englannin kielen asiantuntijan niistä kirjoittamiin tiivistelmiin. Tämän jälkeen selvitettiin, kuinka paljon pääkohtia löytyi opiskelijoiden tiivistelmistä. Lisäksi tutkimuksessa määriteltiin alkuperäisten tekstien tekstityypit ja rakenteet yksityiskohtaisesti. Rakenneanalyysien perusteella valittiin teksteistä niiden rakenteen kannalta tärkeimmät kokonaisuudet. Tämän jälkeen selvitettiin, ovatko opiskelijat sisällyttäneet nämä kokonaisuudet tiivistelmiinsä ja täten tunnistaneet alkuperäisissä teksteissä käytetyt rakenteet.

Tutkimuksen tulokset osoittavat, että tekstin rakenteen tunnistaminen auttaa sen tärkeimpien kohtien löytämisessä. Epäselvä tekstin rakenne näyttää aiheuttavan useille opiskelijoille ongelmia tekstin pääkohtien paikantamisessa. Lisäksi sekä alkuperäistekstin pääkohtien löytäminen että sen rakenteen tunnistaminen helpottavat tiivistelmän kirjoittamista ja parantavat sen laatua. Myös rakenteen monimutkaisuus vaikeuttaa tekstin ymmärtämistä ja tiivistelmän kirjoittamista, suoraviivainen ja looginen rakenne on helpompi tunnistaa. Englantia toisena kielenä opiskelevilla on vaikeuksia tekstin ymmärtämisessä ja tiivistämisessä myös siksi, että he lukevat ja kirjoittavat vierasta kieltä. Englannin kielessä käytetyt tekstirakenteet eivät näin ollen ole heille välttämättä tuttuja. Lisäksi tiivistelmän ongelmat saattavat johtua myös vaikeuksista tuottaa tekstiä vieraalla kielellä.

Opiskelijoita tulisi tutustuttaa kouluissa erilaisiin, myös vieraskielisiin, tekstirakenteisiin ja niiden analysointiin. Monenlaisten tekstirakenteiden tunnistaminen auttaisi paitsi tekstien ymmärtämisessä myös kirjoittamisessa.

Asiasanat: ESL, ESP, reading comprehension, text structure, summary writing

CONTENTS

1. INTRODUCTION

Nowadays it is essential for many people, at least in the developed countries, to be able to read and write English fluently. English as an international language is so important that many people are required to use it almost every day. Especially in natural sciences and technology subjects a great deal of the professional and academic communication is in English. Thus it is important that the students and professionals in these fields are able to understand and use the special English language of their subject areas. Without English language skills it is hardly possible for them to cope with the materials in their studies and to keep up to date with the newest developments in their fields.

As a result of above mentioned facts, it is important to study the state of students' and professionals' competence in English, for example, their English reading comprehension and summarizing skills. Summarization task is one way to test reading comprehension although it also requires the ability to produce texts. Researchers argue that most learning in schools is dependent on the ability to learn and understand expository texts. Furthermore, one important aspect in comprehension of texts is identifying the most important information in them. Summarizing involves both of these skills, ie. understanding of texts and the ability to identify important information. Efficient summarizing is often required in academic fields, for example students have a constant need of taking notes and summarizing information when studying and trying to keep up with the surge of new information.

In addition to reading comprehension, the summarization task requires the ability to produce texts as well. The production stage becomes crucial when one is summarizing in a foreign language. Thus, among ESL students both text comprehension and production may cause problems in the process of summarizing, and this has to

be taken into account when studying their summarization skills.

Because the summarization task is an indicator of reading comprehension and the ability to produce texts, it is a reasonable way to test students' English language skills. Students and professionals summarize every day – at school, at work, and in every-day life – and summary writing is also used in schools to test text understanding.

In the present study the summarization skills of Finnish engineering students are analyzed using summaries produced by the students of texts of their own field. The English language used in the field of science and technology differs from the so-called common or general English. This so called English for Specific Purposes (ESP), or more specificly English for Science and Technology (EST), uses the same elements and structures as general English but in ways specific to the field in question. Actually, it can be said that both ESP and general English are sublanguages of the total English language system which sometimes utilize the language in their own specific ways. ESP research studies different aspects of ESP texts, which are often expository, descriptive, argumentative, or instructive texts, or mixtures of these. There is a need to study ESP texts because they have been largely neglected by researchers, unlike narrative texts.

In this study I intend to combine research in reading comprehension and summarization with ESP research. I collected data in the Tampere University of Technology by asking Finnish engineering students to summarize two English texts of their own field. At the time of the data collecting the students were taking part in an advanced English course dealing with technical vocabulary and materials, and the texts used were taken from their course material. Some researchers who have studied summarization have used manipulated texts in their studies but the texts in this study are authentic. Even though the structure of authentic texts is often complex, it is important to find out how students cope

with them since they will have to deal with authentic texts in their future work.

In the theoretical background of this study I will first discuss ESP research in general and present a number of ways of classifying ESP texts into different types. Next, the concept of text structure will be dealt with, and different ways of analyzing text structures are presented. Further, the theoretical background includes discussion on reading comprehension and the aspects involved in it as well as the relationships between text structure and summarization and reading comprehension. Definitions of summary and the process of summarization is the fourth topic, and, finally, earlier research on summarization and, more specificly, on ESL summarization will be discussed.

After the theoretical background the data, aims and methods of the present study will be described. Next, in the analysis section, the types and structures of the texts used in the study will be analyzed. Then the students' summaries will be analyzed by considering the following aspects: inclusion of the main points of the original texts and sensitivity to the structures of the original texts. The relationship between these aspects will be discussed as well, because they both play an important role in summarization.

To sum up, the aim of the study is to find out how competent Finnish technology students are at reading, comprehending and summarizing English texts of their own field. The performance of the students in the summarization task is dependent on their ability to write English, and this aspect will be discussed in the Discussion and Conclusion section. The approach of the study is qualitative. The number of subjects is small (10-11) and, consequently, the results cannot be assumed to apply to large number of cases.

2. THEORETICAL BACKGROUND

2.1 ESP research

The field of ESP research concentrates on the English special languages used in different subject areas. This section gives a short account of the historical development of ESP research and presents the main theoretical issues of the field.

There are some minor differences in the ways in which various researchers report on the historical development of ESP research. However, most of them agree that the general direction of the development has been from the lexical or terminological concentration to a functional or communicative emphasis and finally to a text-oriented approach (Schröder 1991:9; Gnutzmann and Oldenburg 1991:103-105; Hutchinson and Waters 1987:9-12). In other words, it can be said that the focus of ESP research has gradually shifted from the level of morphemes and words to sentences and finally to entire texts, or as Gnutzmann and Oldenburg (1991:105) put it, from microlinguistic level to macrolinguistic level. This shift of focus took place in the early 1970s in linguistics and the phase of textlinguistics in ESP research began in the 1980s. Thus the development of ESP research has mirrored the trends set by general linguistic theories. (Gnutzmann and Oldenburg 1991:105.)

The main concentration of ESP research today is on ESP texts and their features. This concentration links modern ESP research closely to the field of textlinguistics whose sole purpose is to study aspects of texts. However, the connection between ESP research and textlinguistics is not yet even close to being sufficiently explored, because, as Schröder (1991:11) argues, the field of textlinguistics has for many years typically confined itself to the study of narrative texts. Thus ESP texts, which often contain argumentative and explicative structures, have not been studied textually very thoroughly.

However, several researchers agree on the

usefulness of studying ESP and analysing ESP texts from
the textlinguistic point of view (Gnutzmann and Oldenburg
1991:105; Hoffmann 1991:158-160; Göpferich 1995:305-306).
According to Gnutzmann and Oldenburg (1991:105), for
example, textlinguistic approach has, among other things,
drawn attention to the following linguistic properties of
ESP texts: the meaning of single communicative acts, the
meaning of text structures, and the question of
differentiating ESP text types. Moreover, Hoffmann (1991)
lists several pragmatic advantages of studying ESP
textually. These are, for example, the need for academic
professionals to familiarize themselves with a variety of
text types, the need for everyone to master some
standards of textuality (e.g. cohesion, coherence,
acceptability), and the need to develop a system for
describing different kinds of ESP texts. Further,
Hoffmann argues that textlinguistics has drawn attention
to the following facts: the genuine units of
communication are texts; texts are produced according to
rules; and texts fall into significantly different types
and forms. Another advantage of the textlinguistic
approach is that in it ESP texts are considered very
thoroughly: according to textlinguistics the linguistic
character of an ESP text includes macrostructure,
coherence, theme-rheme progression, functional patterns,
and lexical and morphological features - and is the
result of various combinations of all these factors.
Moreover, textlinguistic approach consideres the role of
the writer of the text and his/her intentions as well as
the role of the reader and his/her expectations.
(Hoffmann 1991:160-161.) Thus, textlinguistics looks at
ESP texts from a holistic point of view, trying to take
into account all of their properties.

One of the most important tasks of textually
oriented ESP research is the detailed description and
exact differentiation of ESP texts. However, in order to
differentiate, compare and analyse text types a text
typology is needed as framework. (Göpferich 1995:305.)
Moreover, knowledge of different text types and their
specific linguistic features helps in the usage of

language, for example, in composing texts (Hoffmann 1991:159). Finally, there is evidence that recognizing different text types and their communicative and linguistic structure is a crucial part of international technical communication, and often insufficiently mastered by students (Gnutzmann and Oldenburg 1991:109). Thus, knowledge of different text types and their linguistic properties has been found essential in the areas of research, professional life, and education.

The ways of differentiating and describing text types vary somewhat depending on the researcher in question and his/her purposes. A well-known general text typology is found in Werlich's (1983) book A Text Grammar of English. Werlich distinguishes five basic text types: description, narration, exposition, argumentation, and instruction. It is important to notice that this classification is based on idealized norms which more or less have the text structuring and elements typical of a certain text type. When writing a text, the encoder may try to compare the context of the text to the above five text types above, and, on the basis of that comparison, decide on the most appropriate one. Werlich has grouped texts together on the basis of their dominant contextual focus and assigns each text type a few typical features. **Descriptive** texts primarily deal with factual phenomena in **space** and are related to the cognitive process of perception in space. **Narrative** texts have to do with phenomena in **time** and involve the cognitive process of perception in time. In **expository** texts the encoder presents constituent elements which together form a composite concept ('term') or a mental construct ('text'). Thus, in expository texts these component elements interconnect in a meaningful whole. The cognitive process present is comprehension and the typical sentences either identify or link phenomena together. In **argumentative** texts the cognitive process is judging; the encoder's propositions disagree with deviant or alternative propositions. Sentences typical of argumentative texts are quality-attributing sentences. Finally, the main idea of **instructive** texts is telling

someone what to do, that is, giving instructions. Planning is the primary cognitive process in instructive texts. (Werlich 1983:39-41.) In practice, a text may have features typical of several text types and it is not possible to assign it only one type but several, one of which may be dominant.

On the basis of Werlich's typology it can be stated that most ESP, and especially EST, texts are, as mentioned above, descriptive, expository, argumentative, or instructive. Werlich's typology is meant to apply to all texts but other reseachers have concentrated on LSP texts only. For example Hoffmann (1987a and 1985, as quoted by Gnutzmann and Oldenburg 1991:110) bases his classification of LSP texts on the **horizontal stratification**, that is, the subject area of the text, and on the **vertical stratification**, or the level of abstraction, of the text. In Hoffmann's model there are five different levels of abstraction into which texts of various subject fields fall. Level A includes texts of the highest level of abstraction, belonging to theoretical, pure research subjects such as mathematics. The last level, level E, in turn, includes texts of very low degree of abstraction, such as consumption texts. Texts belonging to levels B, C and D are placed between levels A and E in the typology.

Schröder (1991:18-19) expands Hoffmann's text classification model further. When analysing LSP texts, it is, in his opinion, important to take into account, in addition to horizontal and vertical stratification, the following aspects: the scientific paradigm (e.g. methodology), the destination (theoretical, applied or empirical research), the communication situation (participants, locations, moment, purpose, and intention), and the dominant text type. Schröder (1991:19) argues that these variables determine certain conventions in texts and are affected by the culture and language in question.

The classifications for LSP texts by Hoffmann and Schröder are, as Schröder himself (1991:4) and Gnutzmann and Oldenburg (1991:105,110) argue, quite vague

and based largely on the researcher's intuition. This is due to the fact that not many have ventured to carry out empirical analysis on the basis of their classifications (Gnutzmann and Oldenburg 1991:105). A text typology by Göpferich (1995), however, provides quite a practical and comprehensive model for differentiating ESP texts, and she has used it in practice as well. Göpferich concentrates only on EST texts, that is, texts of science and technology, and this has made it possible for her to be quite exact in the classification. The typology is hierarchical and consists of five levels: 1) ESP text categories, 2) 1st order ESP text subcategories, 3) 2nd order ESP subcategories, 4) Primary text types, and 5) Secondary text types. Each level has its own differentiation criterion and not every ESP text category has subcategories on each level. On level 1 the differentiation criterion is the text's communicative function, on level 2 it is theory vs. practice, on level 3 the way in which information is presented, and on level 4 the text's primary function. Level 5 includes secondary text types which are often abstracts or reviews of the primary text types and may belong to a different ESP text category (Göpferich 1995:309-315.) Göpferich's typology has been used to determine the text types of the two texts in the present study and a diagram describing the model in detail can be found on page 33.

2.2 Text structure

In Werlich's definition of an expository text both content and structure determine the type of the text. Structure of a text can be defined as the way ideas are organized in a text (Armbuster, Anderson and Ostertag 1987:332). Moreover, according to Meyer (1985:12-13), the structure of a text binds it together and determines the central ideas as opposed to those that are more irrelevant. In other words, the author of the text uses the overall organization to show how some ideas are more important to his message than others. Structure is the factor that primarily differentiates texts from simple

lists of facts. (Meyer 1985:12-13.) From this it follows that, in order to read and comprehend a text, the reader should be aware of its structure. Research has shown that sensitivity to text structure is an important component in reading comprehension. (Armbuster, Anderson and Ostertag 1987:333; Golden, Haslett and Gauntt 1988:156; Berkowitz 1986:162; Cook and Mayer 1988:448.)

Given the importance of text structure in text linguistic research and reading comprehension, it is not surprising that researchers have analysed different text structures and studied how readers utilize them when reading. First, however, it is useful to explore some ways in which different kinds of text structures may be divided. As mentioned above, Wehrlich has divided texts into five different types. Of these types only expository texts will be discussed in more detail here because both of the texts involved in this study are expository. In addition to Wehrlich's definition given above, expository texts may be defined as non-literary and non-narrative hierarchically organized texts in which the author presents information to the reader and explains it (Seidlhofer 1995:8-9; Taylor 1982:323). Further, in expository texts the structure determines the logical connections between ideas and shows the subordination of some ideas to others (Meyer 1985:13). Expository texts may be manifested in different structures some of which will be discussed in what follows.

Researchers differ somewhat in their opinions of what typical expository text structures there are and what these structures should be called. The following list of possible structures of expository texts is a combination of several researchers' suggestions: collection, description, generalization, enumeration, comparison/contrast, classification, cause/effect, problem/solution and temporal sequence (Meyer 1985:11; Armbuster, Anderson and Ostertag 1987:333; Cook and Mayer 1988:449). More than one structure can be present in an expository text at the same time but, as Meyer (1985:12) argues, one logical relationship is usually dominant and defines the superordinate relation in the text.

As shown above, expository texts are highly
organized and they can be analysed on different levels
(Hoey 1983:11,15; Seidlhofer 1995). According to
Seidlhofer (1995), there are four levels of structure on
which it is possible to analyse texts: sentence
structure, thematic structure, semantic structure and
rhetorical structure. However, she argues that approaches
functioning on the levels of semantic structure and
especially rhetorical structure are more advanced than
the others because they concentrate on the entire text
and can be helpful in finding the important information
in a text. A text analysis and reading comprehension
model by Kintsch and van Dijk (1978) and a meaning
relations model by Kauppinen and Laurinen (1984, 1986)
concentrate on the semantic structure of the text. The
models of analysis by Meyer (1985) and Hoey (1983), on
the other hand, emphasize the rhetorical relationships in
a text. In the following, these four models are presented
briefly.

2.2.1 Semantic structure

According to Kintsch and van Dijk (1978:363) there are
two levels of semantic structure in a text: the local
microlevel and the more global macrolevel. The reader
interprets the text as a set of propositions and various
relations between these propositions. Microstructure is
formed by the individual propositions and their
relations, whereas macrostructure describes the higher-
level structure of the entire text. The purpose of the
reader is to identify the macrostructure of the text and
thus find the most important information in it. This
hierarchical ordering of the propositions can be done by
identifying the arguments (content) and repetitions in
each proposition, and by using intuition. (Kintsch and
van Dijk 1978:365,367.) In other words, repeated words in
a text characterize the highest levels of information in
this model, and the superordinate relation is found on
the basis of intuition (Meyer 1985:12). Seidlhofer
(1995:81) states that Kintsch and van Dijk's model is a

useful framework for text analysis but cannot be used as such because the concepts it uses and their relationships are not clearly defined. Moreover, the model is not very practical when logical relationships in a text need to be determined because it concentrates more on content items (Meyer 1985:31).

Kauppinen and Laurinen (1986:25) introduce a text analysis model that describes the meaning relations between propositions in a text in a diagram form. The main point in this analysis is that each proposition consists of concepts and relationships between these concepts. However, a text is not just a pile of propositions but the propositions are linked to each other through associative meaning relations. The reader is provided with a diagram which contains a set of important questions. These questions help the reader to find the important information in a text and to arrange it in a diagram. An example of the meaning relations diagram can be found on page 49 in this study. Pitkänen-Huhta (1989:31) uses the meaning relations diagram in her study of summary writing and argues that it is useful in her analysis because it has to do with the whole text, not individual propositions, and in summarization the entire text must be considered. Moreover, it is not dependent on the linear organization of ideas in the text but only on the relations between them (Pitkänen-Huhta 1989:27). From this it can be concluded that Kauppinen and Laurinen's model may be better in analysing texts that are not so well-organized than the rhetorical models below.

2.2.2 Rhetorical structure

Meyer (1985:16) argues in her theory that, in addition to microproposition level and macroproposition level, a text also has a top-level structure, which is the overall organization of the text as a whole. In the analysis procedure the reader's goal is to form a content structure of the text. This content structure includes the content, cohesion and staging of the text. First, the

reader has to determine the top-level structure, that is, the rhetorical relationship that can subsume the greatest amount of the text. The logical relationships found in expository texts require certain elements in the text, for example, the problem/solution relationship requires that a problem and its solution are discussed. On the basis of these logical relationships the reader is able to form a hierachical content structure of the text and arrange the information according to its importance. The reader or the analyst is assisted in the analysis by different signalling words in the text which indicate its organization. (Meyer 1985:21-24.) Seidlhofer (1995:125) praises Meyer's model for the fact that it requires careful thinking about the relationships between ideas in the text and also for the fact that it relates content and structure and makes the relationship between them explicit. However, the model is critizised as well because, according to Seidlhofer (1985:125,127), Meyer unjustly supposes that ordinary readers behave like expert analysts, that all readers have similar schematas and that her model is sufficiently clear and well-defined.

Hoey's (1983) analysis model resembles Meyer's model. He also bases his analysis on logical relations between ideas in a text. These relations are called clause relations and can be divided into two classes: logical sequence relations and matching relations. Logical sequences may be, for example, Cause-Consequence, Condition-Consequence and Instrument-Achievement. An example of matching relations is Contrast-Combatibility. The organization of whole texts is described with combinations of relations called patterns. Hoey discusses mainly the Problem-Solution pattern but also patterns involving General-Particular and Matching patterns are described. (Hoey 1983:18-19,31.) By applying different techniques and identifying different signalling elements in a text it is possible to determine its pattern and the meaning of the different sequences and relations found in the text. These techniques and signalling elements are paraphrasing, elaborational interrogation and lexical

signalling. For example, in a Problem-Solution pattern two kinds of relations may occur: the Instrument-Achievement relation and the Cause-Consequence relation, and both have their own signalling elements by which they can be reqocnized. (Hoey 1983:36-42.) Hoey's model will be discussed in more detail in the Analysis section of this study.

Text structure plays an important role in reading comprehension and summarization. A summary can be briefly defined as "a short written or spoken account of something which gives the important points but not the details" (Collins Cobuild English Language Dictionary 1992). Thus, in a summary the main points of the original text should be included. Several researchers have studied the role of text structure in reading comprehension and summarization (e.g. Armbuster, Anderson and Ostertag 1987; Berkowitz 1986; Cook and Mayer 1988; Golden, Haslett and Gauntt 1988; Taylor, B. 1982; Taylor, K. 1986). In all these studies the findings indicate that readers who are sensitive to text structure are better comprehenders and summary writers than those who do not recoqnize the structure. Moreover, it has been found that instruction on text structure and the use of structure strategies when reading improve the readers' text comprehension and summary writing (Armbuster, Anderson and Ostertag 1987:345; Berkowitz 1986:176; Cook and Mayer 1988:453; Taylor 1982:338). The subjects of these studies were mostly children but for example Cook and Mayer studied college students. It seems that skilled readers are more aware of text structures than poor readers and, on the basis of this knowledge, better able to identify the important ideas in a text (Golden, Haslett and Gauntt 1988:143). In studies where sensitivity to text structure is examined, it is generally taken to be indicated by the subjects' use of the organization of the original text in their summary or recall protocols (Golden, Haslett and Gauntt 1988:144; Armbuster, Anderson and Ostertag 1987:332; Berkowitz 1986:163).

Moreover, it has been established that children have more difficulties in identifying main ideas in ill-

structured texts than in well-structured texts. Contrived texts, that is, instructional and practice texts used in reading skills courses are usually well-structured and the main ideas often explicit. Naturally-occurring texts, however, may be ill-structured and are likely to utilize a variety of text structures. Further, the main ideas of naturally-occurring texts may be implicit. The structures used in naturally-occurring expository texts (e.g. cause/effect, comparison/contrast) are more complex than the simple listing structure often present in contrived texts. Thus, the structures frequently utilized in naturally-occurring texts should be used in instruction and studied more. (Hare, Rabinowitz and Schieble 1989:74-75,87.)

2.3 Reading comprehension

As mentioned above, according to Kintsch and van Dijk (1978), the reader forms a macrostructure of the text during reading comprehension. In addition to the model presenting the semantic structure of a text on two levels (microstructure and macrostructure), Kintsch and van Dijk (1978:364) present also a model describing the psychological processes underlying reading comprehension. These two models are closely related to each other since the structure of a text plays an important role in reading comprehension.

In Kintsch' and van Dijk's reading comprehension model the reader first checks the text for its referential coherence, that is, whether or not there is argument overlap among all the propositions. If the text is coherent the processing can continue but if it is not, the reader has to make inferences about the text in order to establish coherence. Due to limitations in working memory capacity, the checking of referential coherence and addition of inferences when necessary cannot be done to the entire text at the same time. Thus, the text has to be processed sequentially and in chunks of several propositions at a time. The size of these proposition chunks is dependent on the surface structure of the text

and reader characteristics. (Kintsch and van Dijk 1978:367-368.)

The text is processed in cycles and from this it follows that there has to be some way in which the propositions already processed and the new information are connected. This is done with the help of a short-term memory buffer: in each processing cycle some propositions remain in the short-term buffer and the aim is to connect them with the input propositions of the next processing cycle. The connections are found, as already mentioned, in argument overlap among the propositions. If connections are found between all propositions, the text is accepted as coherent, but if not, the reader has to initiate inference processes. The process is claimed to be fully automatic and therefore not very demanding on resources. However, if the reader cannot find connections between input propositions and those remaining in short-term buffer, a search of all previously processed propositions has to be made and this is resource-consuming. (Kintsch and van Dijk 1978:368,372.)

The model proceeds through the whole text as described and results in a coherence graph of the text. The propositions that are chosen to the short-term buffer frequently are likely to be stored in long-term memory and recalled better than others. Thus, the propositions including the most important information should be selected to the short-term buffer. One strategy for identifying the important information is to look for propositions that are already connected to many other prositions. These kinds of propositions are likely to be relevant in the next processing cycle as well. (Kintsch and van Dijk 1978:368-369.)

It is obvious that the model described above is not comprehensive. Several important components of reading comprehension are missing in it. Kintsch and van Dijk's model concerns only the microstructure level of comprehension (Miller 1985:211). They do, however, discuss the comprehension processes involved on macrostructure level as well. According to Kintsch and van Dijk (1978:366), the reader must not only relate the

individual propositions in a local manner but also find the more global structure of the text. This structure can be identified in terms of semantic macrostructures. Microstructure and macrostructure are connected with semantic mapping rules called macrorules (deletion, generalization, construction). These rules reduce and organize the detailed information of microstructure and help the reader to find the macrostructure, that is, the gist of the text. (Kintsch and van Dijk 1978:366.)

Further, the application of macrorules is controlled by three kinds of schemata: the reader's goals, conventional text types and world knowledge. Readers often read with a special purpose in mind and this purpose naturally has an effect on what information they consider relevant in a text. Moreover, knowledge about different conventional text types help readers to create expectations of the text and identify important information. Finally, world knowledge, that is, knowledge about the normal ordering of events assists the reader when making inferences in text comprehension and production. (Kinstch and van Dijk 1978:373,375.) Kintsch and van Dijk (1978:371) mention text familiarity as one factor in reading comprehension as well. The reader's prior knowledge determines to a great extent the meaning he or she assigns to a text. Further, the complexity of the surface structure of a text has an effect on comprehension. It has been established that unfamiliar material and complex text structure decrease the size of short term memory processing chunks and thus make the comprehension process more difficult. (Kintsch and van Dijk 1978:371.)

Kintsch and van Dijk discuss many components involved in reading comprehension but they do not really **include** the three kinds of schemata and the role of the reader in their model. Kintsch and van Dijk (1978:389) admit that the model is not comprehensive; it has to do with coherence and gist formation as components of comprehension. However, as Seidlhofer (1995:73) argues, Kintsch and van Dijk seem to assume that all readers read texts in the same way, that is, according to their model,

and that they can speak for all language users. Moreover, they mention different kinds of schemata in connection with reading comprehension but do not determine how schemata in fact affect the process and what the relationships are between different schemata. Furthermore, reading is interactive; the reader interacts with the text and the reader and the writer interact with each other. Therefore, the reader's individual properties such as beliefs, opinions, purposes and interests are involved in comprehension and they are not predictable or generalizable. From this it follows that it seems in fact impossible to develop a generally valid model of discourse comprehension that would apply to all cases and account for all the processes involved. (Seidlhofer 1995:60-80.)

Miller (1985:207) argues that it is not known at the moment how reading comprehension really works. There are gaps in knowledge about the different processes that cannot be filled except with models that are largely based on the intuitions of the researcher (Miller 1985:207). Brown, Day and Jones (1983:977-978) state that in order to learn from texts, the readers must be aware of available learning strategies, of their characteristics as learners (e.g. capacity limitations and background knowledge), the nature of the materials (e.g. text structure and important information), and the nature of the task for which they are learning. Cook and Mayer's (1988:448) list of processes relevant in reading comprehension is as follows: selecting relevant information from the passage, possessing relevant existing information, building internal connections among the elements selected from the passage, and building external connections between elements selected from the passage and existing knowledge. Further, the use of memory structures is added to this list by Black (1985:265).

Kintsch and van Dijk (1978:363) pay attention to text production as well. On the production side their model has to do with the generation of summaries (Kintsch and van Dijk 1978:363). The macrostructure of the text

represents the gist, that is, a summary of the text. However, a summary does not directly reflect the abstract macrostructure because it has the usual properties of discourse such as coherence and connection, but it can be derived from the macrostructure. As mentioned above (p.18), macrostructure can be arrived at by using macrorules. These rules are: **deletion** (of trivial or redundant information), **generalization** (substitution of a concept with a more general concept), **selection** (selection of one proposition and deletion of others that represent the same condition) and **construction** (inventing a macroproposition that represents several propositions in the original). (Kintsch and van Dijk 1978:68-69,72.) Many studies on summarization are based on Kinstch and van Dijk's macrorules. The concepts of summary and summarization will be discussed in more detail in the next three sections.

2.4 Definition of summary and summarization

As mentioned above (p.15) a summary is a short account of the original text that includes the important points but not the details. Several researchers emphasize the importance of comprehending and including the main points in a summary at the expense of trivia (Brown and Day 1983:1; Winograd 1984:405; Johns and Mayes 1990:253). However, while it is essential that the most important information of the original text is conveyed in a summary, also other aspects may be added to its definition. In fact, the definition of a good summary depends on its purpose and different types of summaries may have different requirements. According to McAnulty (1981 as quoted by Johns and Mayes 1990:253), an academic summary is a condensation that conveys the thought, emphasis and and tone of the original, abstracts the significant information of the original, and omits or condenses amplifications such as descriptive details. Moreover, a summary should be readable and intelligible without the original text, cohesive and coherent, linguistically accurate, and it should fulfil its purpose

(Stotesbury 1991:39). Johns (1985:495) adds that subjective comments and interpretations should be avoided when summarizing. Further, a good summary should establish an intertextual link with the original text and follow its structure (Golden, Haslett and Gauntt 1988:144).

Summarizing is considered an important skill in academic and professional environments as well as in every-day life. Most learning has to do with identifying relevant and irrelevant information and summarizing for oneself. Further, summarization tasks have been used in schools to assess students' reading comprehension. (Seidlhofer 1995:2.) According to Stotesbury (1991:30), summarizing is an efficient way to test reading comprehension because it operates on macrolevel and involves comprehension of the global structure, whereas more conventional testing methods (such as multiple choice questions) concern only microlevel. However, comprehension of a text is not the only operation involved in summarization. In addition to reading comprehension also condensation and production are important in the summarization process (Johns and Mayes 1990:253). Thus, it is possible to comprehend a passage but not be able to convey that comprehension in written form (Taylor 1986:206). Similarly, Winograd (1984:423) argues that there is more to summarization than adequate comprehension and that although summarizing difficulties may indicate comprehension problems they may also be symptomatic of difficulties in secondary operations used to condense and transform a text into its gist.

2.5 Research on Summarization

Researchers have established that there is a developmental trend in the ability to summarize and that summarization seems to be a late developing skill. The development of summarization strategies has been studied, for example, by comparing the performances of children to those of older high school students and college students. (Brown and Day 1983; Brown, Day and Jones 1983.) Brown

and Day (1983:1-2) base their study on Kintsch and van Dijk's macrorule theory and compare the summaries of fifth and seventh graders to those of high school and college students. The following summarization rules were identified on the basis of Kintsch and van Dijk's macrorules: deletion (of trivial or redundant material), substitution of a superordinate term (for a list of items and actions), selection of a topic sentence and invention of a topic sentence. The results show that even children know how to delete trivial and redundant information in their summaries but the efficient use of the more complex condensation rules increases with age. Thus, it can be concluded that the deletion rule is the easiest one to use in summarization, superordinate substitution and selection are more difficult, and the most difficult strategy is invention. (Brown and Day 1983:2,7.)

Brown, Day and Jones (1983:968) compared fifth, seventh and eleventh grade students' summaries to high school and college students' summaries. In this study the students' ability to plan ahead, their sensitivity to levels of importance and their ability to condense more information into the same number of words were analysed. College students and high school students outperformed the younger students in all these aspects. On the basis of the results it seems that strategic planning emerges gradually with age, effective planning results in effective summary writing, and strategic action and sensitivity to importance are closely related. Moreover, similarly to the findings of Brown and Day (1983), it was found that younger students use the copy-delete strategy when writing summaries whereas older students use paraphrasing. (Brown, Day and Jones 1983:968-977.)

Children's summarization abilities have also been studied by Winograd (1984:404), who compared good and poor readers in eighth grade in regard of their awareness of the summarization task, identification of main points and ability to transform the text into its gist. The main points were defined by Winograd as those ideas which fluent adult readers considered important and included in their summaries. According to the results,

both good and poor readers seemed to be aware of the task demands of summarization. However, good readers were better able to identify the important elements in the text than poor readers. In fact, poor readers seemed to be aware of what is important but they did not include that information in their summaries. The ability to transform the text into its gist was analysed using a modification of Kintsch and van Dijk's set of macrorules. Better readers used more combinations (of sentences in the original text) and inventions in their summaries whereas poor readers used reproductions. (Winograd 1984:405-415.)

The studies described above have concentrated on children and their summarization strategies, which is understandable because of the pedagogical implications. However, as Johns (1985:497) points out, there is a need to study university students as well. It is important to determine their skills in order to be able to improve the teaching of summary writing also at this level (Johns 1985:497). Johns (1985:498) compared the summaries of so-called underprepared university students (students with low scores in reading and writing) to those of adept students. Again, a modification of Kintsch and van Dijk's model of macrorules was prepared for analysis and evaluation purposes. The results indicate that, compared to expert summaries, academically adept students wrote summaries which included most of the same ideas while underprepared students omitted more ideas in their summaries. Moreover, adept students used more efficient macrorules, such as combinations and generalizations, to produce the appropriate gist of the original text than did underprepared students. (Johns 1985:496,509.)

On the basis of the studies presented above, it seems that efficient summarizers are able to identify the important information and use the macrorules appropriately to produce a gist of the original text. The more sophisticated macrorules used by good summarizers, such as combinations of large bodies of text and inventions of a topic sentence, actually reflect the recognition of the overall structure of the text

(Sherrard 1989:7-8). Several researchers have studied, in addition to the ability to identify the important information, the awareness of text structure in summarization (Golden, Haslett and Gauntt 1988; Armbuster, Anderson and Ostertag 1987; Taylor 1986; Pincus, Geller and Stover 1986). This is where the difference between expository and narrative texts is important; it has been found that expository text structures are more difficult for students to comprehend. However, in academic curricula expository texts are the ones that students have to deal with. Thus it is important to devote attention to the studying of these kinds of texts and how students are able to summarize them. (Golden, Haslett and Gauntt 1988:139.)

Golden, Haslett and Gauntt (1988) investigated eighth graders' summaries of a scientific article and found qualitative differences between them. They (1988:150) noticed that the students who wrote the best summaries were able to identify the problem/solution structure of the original text and used it to organize their own summaries. Moreover, more information was presented in the best summaries than in the poorer ones, and they also had fewer inaccuracies. On the basis of the results, the following implication can be made: recognition of the structure of the input text facilitates the production of written summaries. (Golden, Haslett and Gauntt 1988:150,156.) Similar findings have been reported by Armbuster, Anderson and Ostertag (1987:331), who investigated the effect of instruction of text structure on fifth graders' summarizing abilities. The students in their study were divided into two groups, one of which received explicit instruction on how to recognize a problem/solution structure in a text and how to use it to produce a summary, and the other group practiced reading comprehension by answering short questions about the same text. The results reveal that instruction of structure helped the students to identify the main points of a problem/solution text and to organize and integrate their own summaries better as compared to the traditional instruction group.

(Armbuster, Anderson and Ostertag 1987:334-344.)

Moreover, Pincus, Geller and Stover (1986) and Taylor (1986) found that students often lack knowledge of different text structures and that this deficit causes them to have difficulties in finding the main points in texts. Pincus, Geller and Stover (1986:152) base their study on the assumption that seventh graders do have knowledge of and schemata for stories, that is, narrative texts but not for expository texts. They expect that expository texts are organized in the same way as narrative texts. Therefore, the students were taught to use their existing story schema when reading an event based magazine article and to look for important information everywhere in the article. This way it was easier for them to create expectations of an otherwise unfamiliar text and to find the main points which were scattered all over the article. (Pincus, Geller and Stover 1986:153-157.)

Taylor (1986:196), on the other hand, studied the quality differences between fourth and fifth graders' summaries of expository and narrative articles. According to the results, no quality differences were found between summaries of the two rhetorical forms, but the students themselves reported that the expository article was more difficult to read. Moreover, the summarizers had serious problems in finding and expressing the main ideas of both articles. In the eyes of over half of the students the expository text was difficult to summarize because everything was important and nothing could be left out. Knowledge of structure seemed to be a greater problem with the expository than the narrative text. (Taylor 1986:193-202.) On the basis of these results Taylor (1986:202-203) concludes that the children were not aware that the two articles were written differently, that is, had different structure and thus did not know where to look for the important information. From this it can be concluded, as Sherrard (1989:9) argues, that a 'mature' performance in summarization involves attention to both the content and structure of the original text. Moreover, a mature summarizer is able to condense long stretches of

text and to do this departing freely from the wording and sequence of propositions of the original text. Thus, this strategy considers the text as whole and attacks its deep structure.

2.5.1 Research on ESL summarization

Most university students who study English as second language are required to read and understand academic English texts (Kozminsky and Graetz 1986:3). However, not much research has been done on the summarizing abilities of college level ESL students, although to be able to suggest improvements for teaching it is important to evaluate the summarizing skills of these students. (Johns and Mayes 1990:254.)

It was mentioned above that summarization involves the processes of comprehension, condensation and production. A breakdown may occur in the summarization processes, leading to the production of an inappropriate summary of the original. A breakdown in comprehension may result from difficulties in activating the appropriate schemata, in condensation process information may be lost or confused, and in production some low-level processes, such as syntactic-coding, may be insufficient. It seems probable that these problems in the summarization process increase when the task is performed in a foreign language. ESL students' schemata, that is, background knowledge of conventional rhetorical structures and of the subject matter, are probably different from that of native speakers. Thus, the chance that inappropriate schemata are activated during reading increases and may result in comprehension and summary production problems. Moreover, ESL students' condensation process may break down during the selection and retrieval of the main points. Further, the production process is at least as important for ESL students as the other processes. They may have difficulties in production when, for example, trying to simplify information syntactically and ending up deleting or altering important points. In other words, it is possible that ESL students do not have problems in

comprehending a text but in producing a condensed summary of it. (Johns and Mayes 1990:253-255.)

Although there is an insufficient number of studies on ESL students' summarization skills, some studies do exist. Pitkänen-Huhta (1996:113) does not report any specific differences between Finnish university students' summary performances in L1 and L2, and concludes that among her subjects the language did not play a significant role in the summarization task. However, this finding is probably due to the fact that Pitkänen-Huhta's subjects were students of English and thus mastered the language well. In other studies, where the subjects were probably not as competent, the role of the language seemed to be important. Johns and Mayes (1990) and Stotesbury (1991) use Kintsch and van Dijk's model of macrorules in their studies. Johns and Mayes (1990:253) compared the summaries of ESL university students at two levels of proficiency and developed a coding scheme based on the macrorules for analysing them. It was found that the low level group used more direct copying in their summaries than the high level group. Moreover, the high level group combined more idea units within paragraphs than the low level group. It may be concluded on the basis of these differences that the low proficiency students had more difficulties in applying the macrorules, whereas the high level students were gradually becoming aware of them. Further, both groups had problems with the generalization rule, that is, they failed to condense ideas from the original text, and both groups added their personal comments in the summaries. (Johns and Mayes 1990:264-265.)

Stotesbury (1991:31) compared Finnish history undergraduates' summaries to those written by subject (history) specialists. The students summarized an English history text both in Finnish and English. The results indicate that the undergraduates located the essential features almost as well in both of their summaries as the subject specialists but included more details. Furthermore, the subject specialists used the macrorules, especially generalization, expertly, whereas the students

usually resorted to selection in the form of direct quotes from the original text. Differences were also found between the students' English and Finnish summaries. The English summaries included more direct quotes while in the Finnish summaries there were more extra-textual additions, metatext and misunderstandings. Moreover, the summaries produced in mother tongue were more fluent and coherent than the English ones. Thus, the language of summarization seems to affect the nature of the summary products. (Stotesbury 1991:31-34.)

The other two studies compared native language and foreign language summarization as well but in different ways. Kozminsky and Graetz (1986:8-9) gave ESL university students a text written either in Hebrew (their mother tongue) or in English and asked them to summarize the text in Hebrew. The summaries were then compared and it was found that although there were more generalizations and combinations in the English summaries and more direct copying in the Hebrew summaries the quality of the English summaries was poorer. Further, the English summaries did not follow the organization of the original text as much as the Hebrew summaries. (Kozminsky and Graetz 1986:15-17.)

Finally, Long and Harding-Esch (1986:279) studied the summarization of speech in both native language and foreign language. English and French university students heard one speech in English and one in French and were asked to summarize the speeches in the same language that they heard them. A model summary for each speech was constructed by the authors in order to establish the main points. A second language deficit was found when comparing the summaries. In the L2 summaries there was a significant decrease in main points and in information in general while a lot of false information was added to them. Thus, it seems that, due to this deficit, important information is less efficiently selected and organized during summarization in second language. (Long and Harding-Esch 1986:278-283.)

To sum up, it seems that, when writing a summary in second language, students have problems with

identifying the important information in the original text and including it in their summaries. Second language students also have trouble generalizing information, they do not understand the original text completely and add their personal comments in their summaries. Moreover, low proficiency L2 students cannot apply the macrorules as well as high proficiency students and copy information directly. On the other hand, when reading a text in their native language and summarizing it in L2, students seem to depart from the organization of the original text. The purpose of the present study is to find out whether some of these aspects or others can be found in the summaries of Finnish engineering students and thus shed some more light on the subject.

3. THE PRESENT STUDY

3.1 Data collection

The data of this study consist of, first of all, two short passages taken from the journal <u>Mechanical Engineering</u> (May 1996). The passages are called <u>Reproducing Copying Machines (RCM)</u> and <u>Fresh Green Engineers (FGE)</u> (pp.38,50-51). Finnish engineering students taking part in an advanced English course at the Tampere University of Technology wrote summaries of both passages in English, which are included in the data. Examples of the summaries can be found in Appendixes I-II. The example summaries chosen in the Appendixes are the strongest and weakest summary performances of the two texts, when both the inclusion of main points and sensitivity to text structure are considered. Moreover, two experts of English wrote summaries of the same texts which also are included in the data (Appendixes III-IV).

At the first summary writing session there were eleven students present in the class and at the second session ten. Each time the students had about 45 minutes to read the original text and to write a summary of it. The original text was available for them the whole time because recall was not tested in this study. The texts

RCM and FGE were taken from the students' course material but, according to their teacher, they had not been discussed in detail in the class, and thus it is probable that the students did not remember them very well anymore. Both of the texts are authentic, that is, they were not altered in any way neither for the English course nor for the study.

All the engineering students have studied English seven years in comprehensive school and three years in high school. They have also taken part in a basic course of English at the Tampere University of Technology as a prequisite of the advanced course. Both the basic course and the advanced course deal with English technology vocabulary and materials. According to the students themselves, they have not had much experience in writing summaries in English but have summarized mainly in Finnish and at school.

The aim of this study is to analyze the summarizing skills of the engineering students and to find out how competent they are at comprehending English texts of their own field. This is hoped to be found out by analyzing the students' summaries as to the inclusion of the main points of the original texts and sensitivity to the structures of the original texts.

3.2 Methods

First, the texts RCM and FGE will be classified into text types according to the typologies by Werlich (1983) and Göpferich (1995). Next, the structures of both texts are analysed in detail. The structure of RCM is analysed according to Hoey (1983) and the structure of FGE according to Kauppinen and Laurinen (1984,1986). On the basis of these structure analyses also the the main structural elements in the texts are established. Both analysis processes will be described in the Analysis section of the study.

Secondly, the students' summaries are analysed and the following aspects will be looked at: inclusion of main points and sensitivity to text structure. The main

points of the texts RCM and FGE are established on the
basis of the two expert summaries. In other words, the
main points include the information that was present in
the expert summaries, and the purpose of the analysis is
to find out to what extent the students have identified
this important information and included it in their
summaries. Sensitivity to text structure, in turn, is
established on the basis of the structure analyses of the
original texts. The students' summaries are checked for
the inclusion of the main structural elements of the
texts. The degree to which the main structural elements
are present in the summaries helps to determine whether
or not the students can be said to have recoqnized and
followed the structure of the original texts.

4. ANALYSIS

4.1 Types of the texts

As was mentioned above (pp. 6-10) it is useful to
determine the type of the text when analyzing it. There
are various classification systems available for this
differentiation task but in this study the typologies by
Werlich (1983) and by Göpferich (1995) are used. Werlich
presents a well-known general typology for all texts and
using this typology helps to establish the main features
of the texts Reproducing Copying Machines and Fresh Green
Engineers as compared to all kinds of other texts.
Göpferich (1995), on the other hand, concentrates only on
EST texts, that is, English texts of science and
technology, and thus with the help of her typology the
types of the texts can be determined further and with
more accuracy.

First of all, RCM and FGE both belong to the
category of ESP (English for Specific Purposes) texts,
since they are texts of a specific field, engineering,
and the language used in them and their structure reflect
the requirements of this field. More specifically, RCM
and FGE are EST texts because engineering is a part of
the field of science and technology. This conclusion is

further supported by the fact that both texts are found in an engineering journal, <u>Mechanical Engineering</u>, which consists of articles in this field.

According to Werlich's (1983) text typology, <u>RCM</u> and <u>FGE</u> are expository texts. Werlich (1983:40) argues that in expository texts the author's purpose is to explain how component elements interrelate in a meaningful whole. The sentences in these kinds of texts are either phenomenon–identifying or phenomenon–linking (Werlich 1983:40). In both <u>RCM</u> and <u>FGE</u> a certain phenomenon is explained: in <u>RCM</u> it is the reproduction of copying machines and in <u>FGE</u> the new engineering education curriculum. All the sentences in the texts have to do with these phenomena. Moreover, the texts do not contain elements typical of any other of Werlich's text types; they do not discuss phenomena in space or phenomena in time as descriptive texts and narrative texts do, nor do they include judging or instructions like argumentative and instructive texts (Werlich 1983:39–40). Some of these elements may be found in the texts, such as phenomena in time in <u>FGE</u>, but not as the main focus of the text.

However, the above definition does not give a very detailed description of <u>RCM</u> and <u>FGE</u>; a more accurate text type analysis is needed in order to establish their nature. Figure 1 below presents Göpferich's (1995) text typology, which concentrates only on EST texts and thus helps in determining the nature of <u>RCM</u> and <u>FGE</u> in more detail.

Figure 1

A PRAGMATIC CLASSIFICATION OF LSP TEXTS

	Written text types of science and technology						**selection/ compression**	
1. LSP text categories (typological base: communicative function)	juridical-normative texts	progress-oriented actualizing texts		didactive-instructive texts			compilation texts	
2. 1st-order LSP text subcategories (differentiation criterion: theory vs. practice)				theoretical texts (uni-directional)	man/technology interaction-oriented texts (bidirectional, application-oriented)			
3. 2nd-order LSP text subcategories (differentiation criterion: kind of information presentation)		plain presentation	sophis-ticated presentation	mne-monically-organized presentation	interest-arousing presentation		encyclo-paedic texts	sentence-fragmen-tary texts
4. Primary text types (PTT; classified according to their primary function) selection/ compression	standard, specification, patent specification, etc.	report (e.g. research ~, damage ~), conf.proceed., monograph, dissertation, article in learned journal, etc.	article in learned journal, etc.	textbook (school ~, university ~, etc.), etc.	popular science article, non-fiction, product information, etc.	operating instructions, manual (owner's ~, user's ~, work-shop ~), etc.	encyclo-paedia, etc.	diction-ary, collec-tion of formu-las
5. Secondary text types (STT; occasionally part of PTT, but also autonomous)	abstract, etc.	abstract, review, etc.	abstract, review, etc.	workbook, review, collection of exercises, etc.	summary, review, etc.	reference manual, reference card, review, etc.	review, etc.	review, etc.

At the first stage, <u>RCM</u> and <u>FGE</u> seem to fall into the category of didactive-instructive texts. The only other category on this level that would be possible for them is the progress-oriented actualizing texts. However, according to Göpferich (1995:308), these texts convey information the purpose of which is to advance science or technology and always present new research results and findings. <u>RCM</u> and <u>FGE</u> do not fulfill these requirements but rather the requirements of didactive-instructive texts which convey information for the purpose of intellectual enrichment, entertainment or practical application (Göpferich 1995:308).

At the second stage of Göpferich's typology <u>RCM</u> and <u>FGE</u> belong to theoretical texts rather than

man/technology interaction-oriented texts. This
conclusion is based on the fact that man/technology
interaction-oriented texts are bidirectional and
application-oriented: their purpose is to facilitate the
practical use of objects and they emphasize the
interaction between the user and these objects.
Theoretical texts, in turn, are unidirectional and
provide the reader with general information (Göpferich
1995: 309-313.) Since RCM and FGE do not contain any
specific instructions which the reader should follow, it
seems justified to conclude that they belong to the
category of theoretical texts.

At the third stage of the diagram RCM and FGE
can be placed to the category of interest-arousing
presentation. This is because in mnemonically organized
texts information is presented so that it is easily
learnt, that is, they often contain, for example,
mnemonic verses, coloured boxes and refresher questions.
Texts with interest-arousing presentation, in turn, are
read for fun or intellectual enrichment, not to be
reproduced later in, for example, a test.(Göpferich
1995:314.) RCM and FGE do not contain any of the elements
typical of mnemonically organized texts. Moreover, they
are found in a journal and not in a textbook, which
further supports the decision that they belong to
interest-arousing presentation texts.

At the fourth stage of the typology, it seems
that the primary text types of RCM and FGE are popular
science articles. After all, they are found in a popular
science journal. In conclusion, then, according to
Göpferich's text typology, the communicative function of
both RCM and FGE is didactive-instructive, and they are
unidirectional theoretical texts with interest-arousing
information presentation. Moreover, the primary text type
of RCM and FGE is a popular science article.

However, although both RCM and FGE are
expository texts and are classified in the same text type
categories in Göpferich's typology as well, there are
differences between them. These differences are in the
structures of the texts. As already pointed out (p.10-

11), expository texts may have different kinds of structures and even the same text may contain features of more than one structure. One possible expository text structure is the problem/solution structure. Texts with this structure convey information about a certain problem encountered by an individual or a group, the ways in which they attempt to solve the problem, and the results of the attempt. (Armbuster, Anderson and Ostertag 1987:333-334.) The text RCM seems to have this problem/solution structure. The main structure of the text FGE, on the other hand, seems to be that of generalization. A passage with the generalization structure has a main idea which the other sentences either clarify or extend. The clarifying sentences explain the main idea with examples and illustrations whereas the extending sentences explain the main idea in more detail. (Cook and Mayer 1988:449.) The structures of RCM and FGE are analysed in more detail in the following sections.

4.2 The Problem-Solution structure of Reproducing Copying Machines

In this section the text Reproducing Copying Machines is analysed according to Hoey's (1983) model of text analysis which was discussed briefly in the Rhetorical structure section (pp.13-15). As mentioned before, Hoey argues that in a text ideas are connected to each other by logical relations. Two kinds of logical relations may be found: logical sequence relations and matching sequence relations. Further, the organization of entire texts is formed by combinations of these relations called patterns. Hoey concentrates in his analysis mainly on the Problem-Solution text pattern, which is arranged primarily by the logical sequence relations. These logical sequences can be related to each other in different ways in a text. The different relations can be identified, first, with the help of explicit signalling elements found in texts and, second, by applying techniques that show implicit relations in texts. The

signalling elements used in Hoey's model are different kinds of lexical signals found in texts and the techniques are elaborative interrogation and paraphrases. For example, the Cause-Consequence relation is one possible logical sequence relation and it can be identified in a text with the help of paraphrasing connectors such as 'because' and 'therefore' or the question 'why?'. (Hoey 1983:30-42.)

According to Hoey (1983:51), a Problem-Solution text includes four basic sequence meanings: Situation, Problem, Response and Evaluation. The variations of the Problem-Solution pattern can be illustrated as follows:

Figure 2
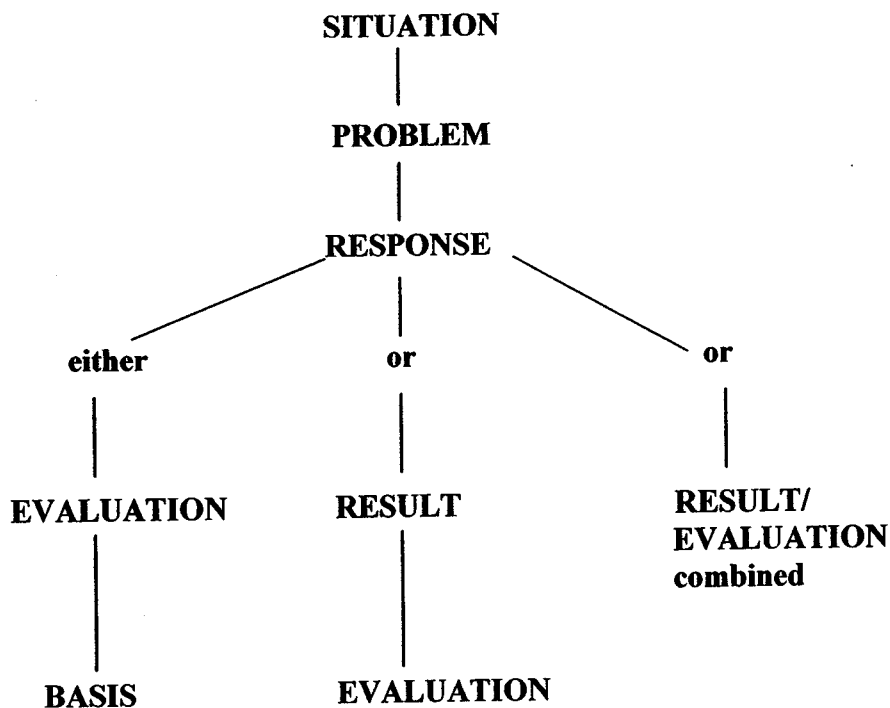
All these meanings can be found and analysed in Problem-Solution texts with the help of the signalling elements and techniques mentioned above. By using elaborational interrogation, for example, Hoey (1983:35,38) shows how the sequence relations may be revealed in a four-sentence example discourse:

```
D: I was on sentry duty.
Q: What happened?
D: I saw the enemy approaching.
Q: What was your response?
D: I opened fire.
Q: How successful was this?
or What was the result of this?
D: I beat off the attack.
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In the example the first sentence has the meaning of Situation, the second sentence the meaning of Problem, the third sentence functions as Response, and the fourth sentence as Evaluation or Result. As an example of the analysis process, the Cause-Consequence relation between the second and the third sentence may be identified. This can be done, for example, by adding one of the typical paraphrasing connectors to the sentences as follows: 'Because I saw the enemy approaching I opened fire.' Another way to identify the relation between the sentences is to use the question 'why?'. The second sentence 'I saw the enemy approaching.' gives the reason for the action taken in the third sentence.

Further, in the example the Evaluation or Result in the last sentence 'I beat off the attack.' is positive, that is, the outcome of the action taken is successful. In real discourses, however, the Evaluation function may be negative as well. In these cases the Negative Evaluation usually introduces a new Problem in the discourse and causes the need to present new Responses, to solve the new Problem. In the end the new Responses need to be evaluated positively because otherwise the discourse does not seem complete. The reader conventionally expects the Problem to be solved in a discourse. (Hoey 1983:82.)

In the following paragraphs Hoey's model of Problem-Solution structure analysis is applied to the text Reproducing Copying Machines and, in the process, described in more detail. For the purposes of the analysis each sentence in the text is numbered. In some cases a major division of function occurs in the middle

*of a sentence and the sentence is divided into two parts. This is the case with, for example, sentence (13). The basis for this conclusion is given below when this sentence is analysed. The text to be analysed in the .following paragraphs is presented below.

Reproducing Copying Machines

(1) Every year some 4 million copiers reach the end of their useful lives. (2) Clearly, just hauling them out to the dump will create impressive mountain scenery in an alarmingly short time, even without further contributions of dead computers, toasters, and cars. (3) But what else can be done?

(4) Several manufacturers - Xerox, Oce', Kodak, and Canon among them - will now take back their old machines. (5) (In the Netherlands, Xerox and Oce' will even collect each other's products, returning them to the original factory.) (6) The devices are taken apart, the components are cleaned, and anything salvageable is sent back to the factory to be remanufactured. (7) Materials unsuitable for remanufacturing are recycled. (8) Oce' estimates that 60 percent of a returned copier can be reused and 35 percent more recycled, leaving only 5 percent as out-and-out carbage.

(9) And it's not just the machines themselves: nonserviceable parts are brought back and remade. (10) Toner cartridges and bottles can also be returned, though this requires some action on the customer's part. (11) Xerox also includes customer-replaceable units in some of its machines that can be taken back, and some photo-receptor fuser parts are returnable as well. (12) Incentives and discounts from the company have resulted in a return rate on these items of about 60 percent.

(13a) Such procedures are likely to be expensive and of limited utility (13b) unless products are designed with these operations in mind. (14) According to James C. MacKenzie, director of environment, health, and safety for Xerox in Webster, N.Y., engineers at that company are encouraged to design products using recyclable and recycled materials. (15) The preference is for avoiding waste at the outset, using components that can be reused with less waste. (16) Formerly, a single machine might contain 100 kinds of plastics and foams, many of them thermosetting; the count is now down to 25 or so, with an ultimate goal of 5 to 10.

(17) Also important is design for disassembly. (18a) Another goal is to design products that use the same basic structure, with any additional features added to standard platform; (18b) this facilitates interchangeability. (19) Of course, increasing products' life spans means less waste in the long run.

(20) In addition to the purely environmental benefits, such efforts also produce savings. (21) MacKenzie noted that the company saves several hundred million dollars a year with its environmental practices. (22) As he said, "Almost any time you do something beneficial for the environment, there's an economic advantage.

First of all, a description of the analysis dividing the entire text into the meanings of Situation, Problem, Response and Result/Evaluation is presented here. After this each section of the text will be analysed in more detail and the basis for the divisions is given. The analysis of the entire text can be illustrated as follows:

Situation: (1)

Problem: (2)

Response: (3)-(7)

Result/Evaluation combined: (8)

Response: (9)-(11)

Result/Evaluation combined: (12)

Negative Evaluation: (13a)

Response: (13b)-(15)

Result/Evaluation combined: (16)

Response: (17)-(18a)

Evaluation: (18b)-(20)

Basis for Evaluation: (21)

Evaluation: (22)

When compared with Hoey's three possible Problem-Solution text patterns described in Figure 2 above, the analysis reveals that the current text belongs to the pattern Situation-Problem-Response-Result/Evaluation combined. Further, a Basis for Evaluation function is found in the text as well. In the following paragraphs, then, the sentences are taken under closer inspection and the reasons for the analysis above are given.

Situation

Sentence (1) has the function of Situation in the text. This sentence describes the state of affairs in the beginning. Lexical signals can be found in the sentence to support this conclusion. The phrase 'every year' indicates the function Situation because it tells the reader what the situation has been for many years before the actions taken to change it. Further, elaborational interrogation can be used to identify the function. The

question 'What is the situation?' is answered by sentence
(1). (Hoey 1983:44,64.)

Problem

The function Problem is represented in the text by
sentence (2). The function can be identified with, first
of all, lexical signals. For example, the word
'alarmingly' used in the sentence indicates that
something is wrong and that the author is alarmed by the
situation. Further, the Problem function of sentence (2)
can be identified with the help of sentence (3). Although
sentence (3) is assigned the function Response in the
analysis it nevertheless refers back to sentence (2).
Sentence (3) indicates that something has to be done to
avoid the danger described in sentence (2) and this is
typical for the functions of Problem and Response. Hoey
(1983:51,54) states that Problem in a discourse is an
'aspect of situation requiring a response' and it is
often signalled by Response function indicating that
something has to be done to prevent the Problem from
happening. Thus, sentences (2) and (3) may be paraphrased
as follows: 'To avoid ... the impressive mountain
scenery...something else has to be done'.

Moreover, paraphrasing connectors may be added
to sentences (2) and (3) in order to reveal the Problem
function of sentence (2), for example, 'Because hauling
them out to the dump will...something else has to be
done'. The fact that the connector 'because' may be added
here indicates that there is a Cause-Consequence relation
between the sentences.

Response

The first sentence which is assigned the function
Response is sentence (3). Following Hoey's (1983:70) line
of argument, sentence (3) can be recognized as a
signalling clause whose purpose is only to signal what
preceeds and follows it. Thus this sentence indicates the
Problem function of sentence (2) and the Response
function of the following sentences (4)-(7).

Sentences (4)-(7) represent the meaning Response

in the text as well. These sentences have similar features and describe the measures taken by some companies to solve the problem presented in the text. Elaborational interrogation may be used to reveal the function of Response of sentences (4)-(7) as below.

> D: Something is being done to decrease the amount of waste created by used copying machines.
> Q: **What is being done? / How is the amount of waste decreased?**
> D: Several manufacturers will now take back their old machines...

Further, it is possible to paraphrase these sentences and sentence (2) with the phrase 'To avoid the problem / prevent the problem from happening'. In the case of sentence (4), for example, the paraphrase is formed followingly: 'To avoid the problem (impressive mountain scenery at the dump) several manufacturers ...will now take back their old machines.' Another aspect found in sentence (4), which is typical of the Response function, is the way it links the Response with a certain participant in the text other than the author. Hoey (1983:103) calls this linking **attribution** and here it is indicated by mentioning that it is the manufacturers that have come up with solutions to the problem and not the author. Moreover, attribution is generally the sentence adjacent to the sentence representing the Problem function and it introduces the Response section in the text. Sentence (4) fulfills these requirements in <u>RCM</u> if the signalling sentence (3) is not counted.

Paraphrasing connectors are helpful in making explicit the Response function of sentences (4)-(7) as well. For example, sentence (4) can be paraphrased as follows: 'By taking back their old machines several manufacturers are trying to solve the waste problem...' or 'Several manufacturers are now taking back their old machines trying thereby to solve...'

Sentences (9)-(11) continue the Response section

in the text. There is actually nothing new in the analysis of these sentences because they merely extend and explain the list of measures and solutions taken by the copying manufacturers in order to solve the waste problem. The Response function of sentences (9)-(11) can be identified using similar techniques as in the analysis of sentences (4)-(7).

Further, sentences (13b)-(15) and (17)-(18) represent the function of Response in RCM as well. Sentence (13b) in a way introduces this new set of Responses by being adjacent to the sentence representing the function of Negative Evaluation, that is, a new Problem, and by stating the general nature of the following Response sentences. The lexical signal found in clause (13b) supporting its Response function is the word 'unless'. The word shows that a response to the new Problem is being offered.

In sentence (14) the attribution is used again, indicating that the measure described in the sentence is taken by Xerox and one of its employees and not by the author. The paraphrase construction 'To avoid the problem / prevent the problem from happening...' is helpful as well, for example, in the following way: 'To prevent such procedures from being too expensive and of limited utility products are designed with...'. This paraphrase shows the Negative Evaluation (new Problem) function of clause (13a) as well as the Response function of clause (13b). Paraphrasing connectors and elaborative interrogation are applicable to sentences (13b)-(15) and (17)-(18) in the same way as with the previous Response sentences.

Result/Evaluation combined

Sentences (8), (12) and (16) have the functions of both Result and Evaluation in the text. All these sentences describe the results of some actions, that is, Responses, but they also have evaluative elements. To illustrate the nature of the Result/Evaluation function, sentence (12) 'Incentives and discounts from the company have resulted in a return rate on these items of about 60 percent' is

taken under closer inspection. First of all, this sentence contains a clear lexical signal of the Result function in the verb 'results'; it shows that the purpose of the sentence is to show the Result of the 'incentives' and 'discounts' mentioned. The Evaluation function in sentence (12) is, however, more subtle. To be able to identify this function one has to understand that the achieved return rate of 60 percent described in the sentence is considered to be high and positive. Thus the lexical signal of Evaluation could be the given percentage '60 percent'.

Furthermore, the Result and Evaluation function of sentence (12) can be established with the help of elaborative interrogation. It answers the question 'What is the result?' with the information that the return rate is now 60 percent, but may answer the question 'How successful are the responses?' as well because the achieved percentage is implied to be high. Similarly, sentences (8) and (16) answer these two questions and lexical signals indicating the function Result/Evaluation combined can be found in them as well.

Evaluation

First of all, there is one clause that represents the function of Negative Evaluation in the text. Clause (13a) evaluates negatively some of the Responses preceeding it and thus introduces a new Problem to be solved in the text. The function of clause (13a) is possible to identify, for example, with the help of lexical signals. The word 'expensive' and the phrase 'of limited utility' both indicate that something negative is discussed in the clause. Moreover, clause (13a) can be considered to present a new Problem on the basis of the fact that it represents an 'aspect of situation that requires a response' in the discourse as the function of Problem tends to do (Hoey 1983:49).

However, there are parts in the text that represent only the function of Positive Evaluation, without the function of Result combined to it. In sentences (18b)-(20) this Positive Evaluation function is

indicated, for example, by lexical signals. These signals are, respectively, the phrases 'facilitates', 'less waste', 'benefits' and 'savings' and they all describe something positive. Similarly, in sentence (22) the words 'beneficial' and 'advantages' contribute to its Positive Evaluation function.

Further, all the sentences with the Positive Evaluation function can be said to answer the questions 'How successful are the responses?', 'What is the evaluation of the responses?' or 'Does it work?'. These questions are typical of the Evaluation function (Hoey 1983:47,78).

Basis for Evaluation

The last function to be analysed in the text RCM is Basis for Evaluation and sentence (21) is assigned this function. The basis for Evaluation function of sentence (21) may be illustrated with, for instance, the following example (Hoey 1983:79,87):

> D: In addition to the purely environmental benefits, such efforts also produce savings.
> Q: **What makes you say that?**
> or **What is the basis for this evaluation?**
> D: Mackenzie noted that the company saves several hundred million dollars a year with its environmental practices.

In the example it can be seen that sentence (21) justifies the positive evaluation in sentence (20).

The main elements of the Problem-Solution structure

After the analysis of RCM above there still remains the question of which of the structural functions in the text are the most important, that is, which functions should be included in a summary. Since Hoey does not really deal with summary writing, he gives no clear answers to this

question. However, he gives some clues and based on them it seems possible to draw conclusions as to which functions and what information should be considered crucial in RCM.

First of all, Hoey (1983:178) argues that if a relation is clearly signalled in the text by the author this indicates that the author considers the relation to be important. By adding clear lexical signals the author ensures that the reader interprets the relation in a certain way. When, on the other hand, a relation can be shown to exist by applying paraphrase or dialogue techniques a more implicit message about the relation is communicated to the reader; (s)he has to base his/her conclusion more on the context and prior knowledge. (Hoey 1983:178.) Thus, the first step on the quest for the most important relations is to look for clear lexical signals.

The relation most clearly signalled in RCM seems to be the relation between sentences (2) and (4). Not only has sentence (2) the lexical signal 'alarmingly' clearly indicating the function Problem but there is also the signalling clause (3) between sentences (2) and (4). As mentioned above, the purpose of the signalling clause is to signal the functions of the sentences that preceed and follow it. Therefore, the function Problem represented by sentence (2) and the function Response represented by sentence (4) seem to be of importance in the text. Another relation in RCM which is shown quite clearly by the author is between clauses (13a) and (13b). These clauses have the functions of, respectively, Negative Evaluation and Response. Since the function Negative Evaluation presents a new Problem in the text, the relation between clauses (13a) and (13b) can be said to be similar to that of between sentences (2) and (4). The lexical signals found in sentence (13) which show the relation between its clauses are the words 'expensive' and 'unless' as well as the phrase 'of limited utility'. Thus, this relation can be said to be crucial in the text as well.

There are other lexical signals in the text as well but the signals mentioned above seem to be the ones

showing relations most clearly. However, Hoey (1983:80) offers another method for extracting the most important structural elements from a text. Since there is no one-to-one correspondence between sentence and function in real discourse, each element of a pattern is usually made up of more than one sentence. These sentences are often on different levels of generalization; for example, the first sentence of a structural element may contain more general information than the sentences following it. (Hoey 1983:52-53,80.) On the basis of this information, Hoey (1983:80) states that it is possible to form a reasonable summary of a text by taking only the first sentence of each structural element, excluding the signalling clauses. He (1983:80) admits that the method is quite crude and may leave out a lot of essential information but, at the same time, it seems to show the communicative core of the discourse. In the present analysis this summarizing method is, however, modified slightly.

First, there is only one sentence in RCM that has the function of Situation. Thus information included in sentence (1) may be said to be important in the text. The same applies to sentence (2) and clause (13a). Sentence (3), being a signalling clause, is not taken into account. However, the following Response function includes several sentences and, according to Hoey's method, sentence (4) contains the most general information and is considered most important. This element of the structure of RCM is, for the purposes of analysis, termed as **Response 1**. Similarly, the first sentences of the other Response functions in the text are taken, and termed, respectively, as **Response 2** (the information included in sentence (9)), **Response 3** (clause (13b)) and **Response 4** (sentence (17)). When choosing the most important from the Result/Evaluation combined and Evaluation functions, however, Hoey's technique is not followed to the letter here. From the sentences representing the function Result/Evaluation combined only sentence (12) is considered to be important enough to be included in a summary. This is because sentences (8) and

(16) only present percentages and figures which can be considered as details. Further, of the sentences having the function Positive Evaluation sentence (20) seems to be the one conveying the most general information and thus it can be said to be the most important.

In summary, the elements of the Problem–Solution structure of <u>RCM</u> which are considered the most important and which should be included in a summary are: **Situation, Problem, Responses 1–4, Negative Evaluation, Result/Evaluation combined** and **Positive Evaluation.** In other words, the subjects in this study should have these elements in their summaries if they have recoqnized the Problem–Solution structure of the original text.

4.3 Meaning relations in <u>Fresh Green Engineers</u>

A short description of the meaning relations model of text analysis by Kauppinen and Laurinen was given above (p.13). For the purposes of this study, however, it is necessary to describe the model in more detail. According to Kauppinen and Laurinen (1984:30), each sentence in a text contains one or more propositions or idea units. The propositions, in turn, consist of concepts and different relationships between concepts. For example, a concept describing action may be connected to other concepts in the following ways:

Figure 3
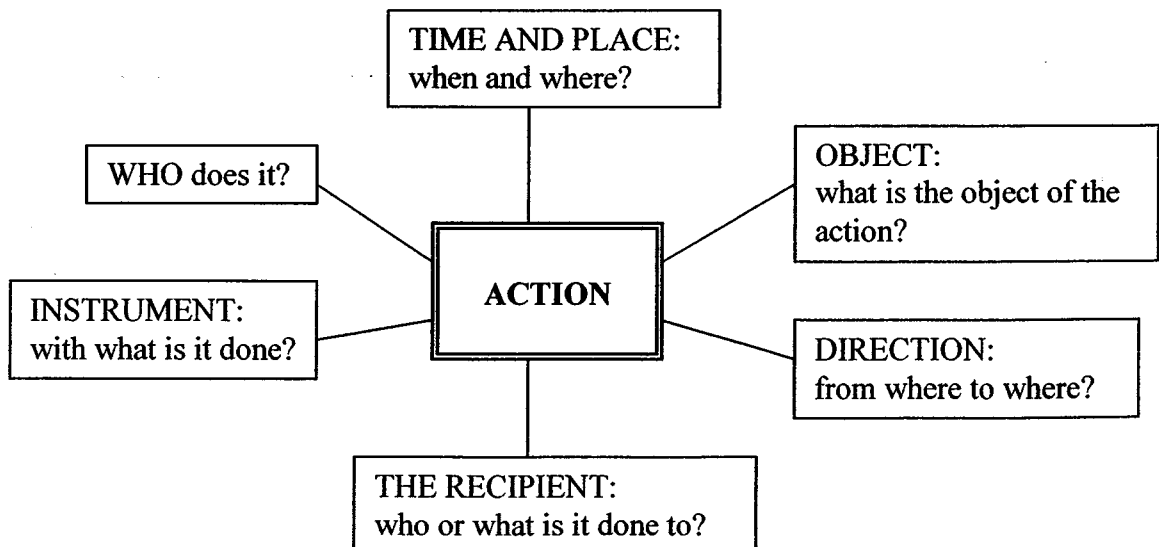
The meaning of the word describing action determines the associative connections which can be attached to it. For example, the verb 'travel' does not allow THE RECIPIENT or THE OBJECT to be connected to it whereas DIRECTION and INSTRUMENT are typical of it. (Kauppinen and Laurinen 1984:30-32.)

In addition to the relationships between concepts within propositions the reader has to be aware of the associative connections between propositions. The identification of these connections is based on text structure and the ability of the reader to comprehend relationships between facts. During reading comprehension the concepts discussed in a text activate other concepts in the reader's memory which are closely related to them semantically. Moreover, the reader makes decisions and draws conclusions about the text on the basis of the ideas presented as (s)he reads. There are some typical ways in which concepts and ideas are connected to each other in memory and in expository texts. These typical connections are: associative connections which define and determine concepts, associative connections concerning the use of the concept, associative connections which illustrate the concept, causal connections and time-related connections (Kauppinen and Laurinen 1984:32-36.)

When analysing a text with the help of the meaning relations analysis the propositions and the associative connections between them need to be established (Kauppinen and Laurinen 1984:43). The aim of the analysis is to describe the entire text with a meaning relations diagram. An example of the diagram for expository texts is presented below:

Figure 4

EFFECTIVE FACTORS

What factors, things or phenomena effect X?

TIME RELATIONS
How has X changed?

THE TEXT'S MAIN CONCEPT X
-What is X (characteristic features)?
-How is X manifested (ways of functioning, forms of
 expression, case examples)?
-What is X aiming at (aims or function)?
-What are the attitudes towards X (emotions, judgements)?

X AND RELATED CONCEPTS
-superordinate, subordinates
-distinctions between concepts (how related
 concepts differ)

CONSEQUENCES
-What is the use of X?
-Drawbacks (what problems does it cause)
-What side effects?

SOLUTIONS
-How does one try to affect X (direct means of influence)?
-How can one affect X (indirect means of influence, which
 affect the causes)?

In the diagram there are a number of questions essential to the content and structure of most expository texts. Answers to all of the questions might not be found in all expository texts because authentic texts differ in their content and structure. Nevertheless, answering at least some of the questions helps the reader to understand and interpret texts. (Kauppinen and Laurinen 1986:28-30.) The first task in the meaning relations analysis is the identification of the main concept. Knowing the main concept usually awakens certain expectations about the meaning relations that are central to the text in question. (Kauppinen and Laurinen 1984:44.)

Each text has its own network of propositions and these propositions form a hierarchy. Some propositions are central to the subject of the text whereas others may function as subordinate propositions, explaining and defining the more central propositions. For example, in expository texts the most important propositions are usually those which determine the characteristics of the main concept, that is, propositions answering the questions underneath the main concept in the diagram above. (Kauppinen and Laurinen 1984:37-38.)

In what follows Kauppinen and Laurinen's meaning relations model is applied to the text Fresh Green Engineers and the analysis process is decsribed in more detail. The text to be analysed is presented below.

Fresh Green Engineers

One challenge in sustainable development is to educate engineers for a new way of thinking. Engineers - and their employers - traditionally have not regarded the environmental costs of their activities as something to be factored into their cost calculations, at least not until lawsuits were filed. To be really effective, such education must start in engineering school.

An ambitious effort to construct an engineering curriculum reflecting concepts of sustainability is currently under way at the Georgia Institute of Technology, in Atlanta. The project, funded by the GE Fund and the National Science Foundation, aims to mold "engineers who are part of the solution, not the problem," says Jorge A. Vanegas, associate director for educational programs for the Center for Sustainable Technology and a codirector of the project.

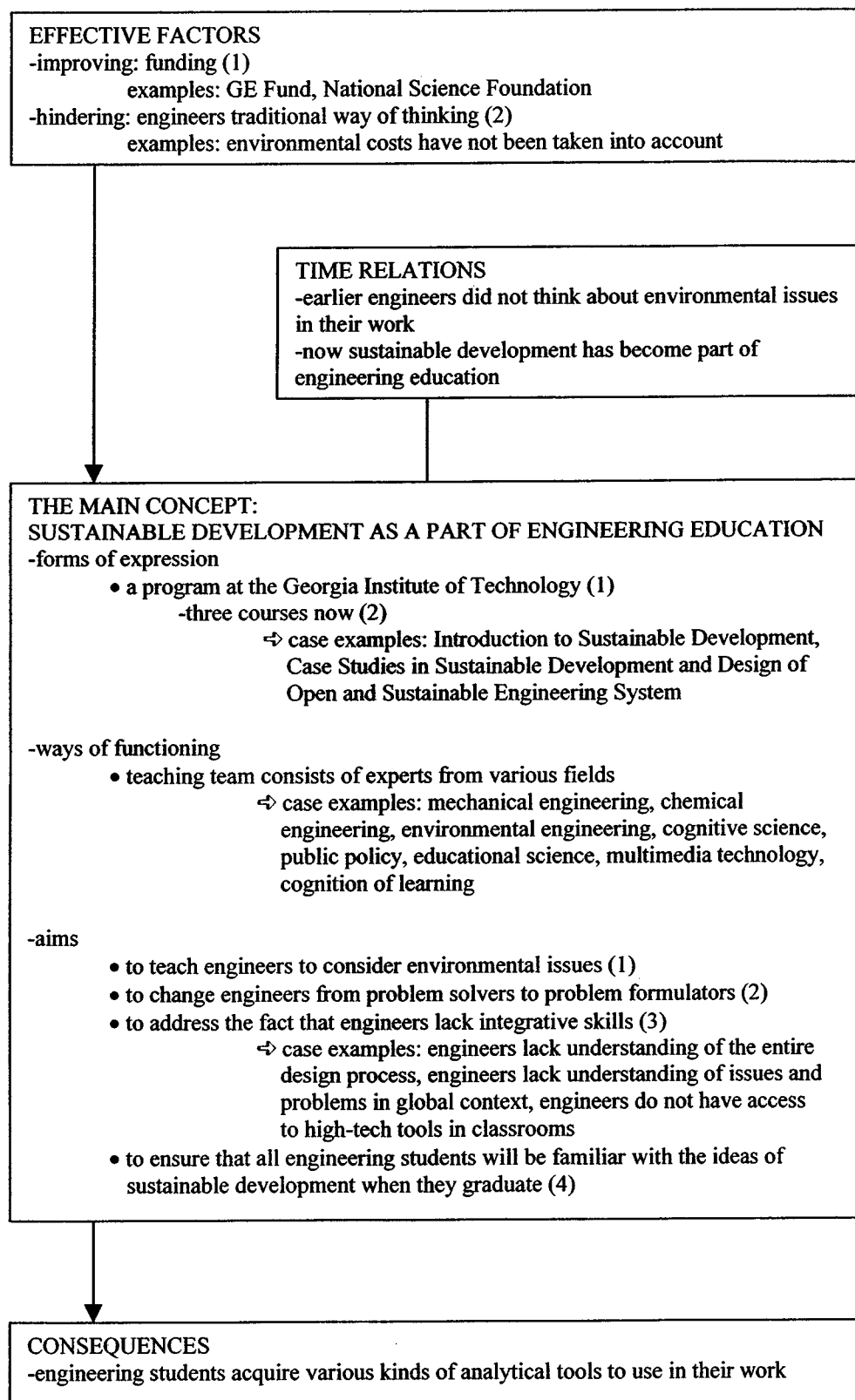The program tries to change engineers' habit of reacting to a

problem and seeking to solve it, says Vanegas. Instead, the idea is to teach them to become leaders in formulating the problems in the first place. The program also addresses what are perceived as problems with engineering education in general, such as lack of integrative skills, that often result when students are shown only one aspect of design at a time rather than the entire process, do not understand issues and problems in a global context, and have limited exposure to high-tech tools in the classroom.

The effort cuts across disciplines. The team responsible includes mechanical, chemical, civil, and environmental engineers as well as representatives from the fields of cognitive science and public policy. There is significant input from the EduTech Institute of Atlanta, a source of expertise in educational and multimedia technology and in the cognition of learning - that is, how people learn. "Engineering students need to acquire the analytical tools to assess risks and impacts; to perform life-cycle analyses; and to solve technical problems within a context defined by economic, sociopolitical, and environmental considerations," Vanegas said.

Three courses are already being taught in the program: "Introduction to Sustainable Development", "Case Studies in Sustainable development", and "Design of Open and Sustainable Engineering Systems". The audience is not limited to engineering students, however. The goal of the project, according to Vanegas, is to "penetrate the curriculum in context". Said John White, dean of Georgia Tech's School of Engineering as well as a founder and former codirector of the project: "We will, by the end of this project, ensure that all engineering students who graduate from Georgia Tech are exposed to the concepts of sustainable development and technology."

Complete description of the text FGE in a meaning relations diagram is given in Figure 5 below:

Figure 5

EFFECTIVE FACTORS
-improving: funding (1)
        examples: GE Fund, National Science Foundation
-hindering: engineers traditional way of thinking (2)
        examples: environmental costs have not been taken into account

TIME RELATIONS
-earlier engineers did not think about environmental issues
in their work
-now sustainable development has become part of
engineering education

THE MAIN CONCEPT:
SUSTAINABLE DEVELOPMENT AS A PART OF ENGINEERING EDUCATION
-forms of expression
    ● a program at the Georgia Institute of Technology (1)
      -three courses now (2)
        ⇨ case examples: Introduction to Sustainable Development,
          Case Studies in Sustainable Development and Design of
          Open and Sustainable Engineering System

-ways of functioning
    ● teaching team consists of experts from various fields
        ⇨ case examples: mechanical engineering, chemical
          engineering, environmental engineering, cognitive science,
          public policy, educational science, multimedia technology,
          cognition of learning

-aims
    ● to teach engineers to consider environmental issues (1)
    ● to change engineers from problem solvers to problem formulators (2)
    ● to address the fact that engineers lack integrative skills (3)
        ⇨ case examples: engineers lack understanding of the entire
          design process, engineers lack understanding of issues and
          problems in global context, engineers do not have access
          to high-tech tools in classrooms
    ● to ensure that all engineering students will be familiar with the ideas of
      sustainable development when they graduate (4)

CONSEQUENCES
-engineering students acquire various kinds of analytical tools to use in their work

As mentioned above, the first step in the
meaning relations analysis is to establish the main
concept of the text. The main concept of the text Fresh

Green Engineers is **sustainable development as a part of engineering education.** The question that this main concept seems to awaken is 'how?'. The reader wants to know more about this new education, for example how it is carried out and what it is like. Underneath the main concept in the diagram are relations which define the main concept and explain how it functions. In the present analysis these are forms of expression, ways of functioning and aims. Forms of expression include the following facts: the program takes place at the Georgia Institute of Technology and three courses are available at the moment. The names of the three courses are given as case examples. Moreover, ways of functioning contain the information that the teaching team of the program consists of experts from various fields. Again, case examples of these fields are provided. Finally, the aims of the program include: to teach engineers to consider environmental issues; to change engineers from problem solvers to problem formulators; to address the fact that engineers lack integrative skills; and to ensure that all engineering students will be familiar with the ideas of sustainable development when they graduate. The concept of integrative skills is elaborated with case examples. Thus, the information that defines the characteristics and functioning of the main concept seems to be crucial in the text FGE. Similarly, Kauppinen and Laurinen (1984:37) argue that in expository texts the associations that determine the characteristics and function of the main concept are on top of the hierarchy in the meaning relations diagram.

Besides the main concept and its characteristics, the diagram includes information about the facts that have an effect on the main concept. The effective factors are found at the top of the diagram and consist of improving and hindering factors. In other words, funding has an improving effect on the main concept; it makes the education possible. The engineers' traditional way of thinking, that is, a way of thinking that does not take environmental issues into account, in turn, has a hindering effect on the main concept because

it is not easy to change long-standing attitudes. It seems that both of these factors affect the main concept directly, and, moreover, they affect all its characteristics. Kauppinen and Laurinen (1984:37) state that effective factors which have an effect on all of the characteristics of the main concept of a text belong to the top of the propositional hierarchy.

There are two more types of associative relations left in the diagram: time relations and consequences. According to Kauppinen and Laurinen (1984:37-38) time relations are usually not very important in expository texts because the ordering of propositions is not dependent on time. Admittedly, time can have an effect on the main concept but the effect is often indirect (Kauppinen and Laurinen 1984:37). In FGE, it seems, time is not a central factor. Time relations are mentioned in the beginning of the text when the engineers' and their employers' traditional way of thinking is discussed. However, the author does not extend this discussion further by, for example, comparing traditional engineering education to the new program through the entire text or by describing the progress of the program step by step.

Meaning relations that have to do with consequences of the main concept, on the other hand, are not mentioned in Kauppinen and Laurinen's discussion of important elements in expository texts at all. In FGE, the information included in consequences is the fact that, as a result of the education program, engineers will acquire various analytical tools. However, this information seems to be implied in the aims and ways of functioning as well. Under the heading 'ways of functioning' there is the fact that the teachers in the new engineering curriculum represent various fields of study. Moreover, one aim of the curriculum is to improve engineers' intergrative skills. Thus, on the basis of these two pieces of information it can be concluded that the engineers taking part in the program will also acquire different kinds of analytical tools.

In summary, then, it seems that, on the basis of

the meaning relations analysis, the most important elements of the passage Fresh Green Engineers are, first, the **main concept** and its characteristics, that is, **forms of expression 1-2, ways of functioning** and **aims 1-4.** Secondly, the **effective factors 1-2** seem to be essential as well. However, consequences and time relations are to be considered less important in the text. In other words, the information included in the main concept and its characteristics as well as in effective factors should be included in a summary of FGE. As with the Problem-Solution structure of RCM, this information will be used as an aid for analysis in this study when determining whether or not the subjects have recognized and followed the semantic structure of the original text FGE in their summaries.

Comparison of the two models of analysis
As a result of the application of Hoey's Problem-Solution model and Kauppinen and Laurinen's meaning relations model above, it seems necessary and useful to evaluate the two models and compare them with each other. Hoey's model is largely based on explicit and implicit signalling in texts whereas Kauppinen and Laurinen's model concentrates more on the content of texts. Kauppinen and Laurinen (1984:17) argue that the meaning relations model does not concern the structural properties of texts at all but only the content. It is true that the meaning relations are not dependent on the written form or the ordering of ideas in texts, and this property is one of the strengths of the model. By establishing the meaning relations the reader is able to get in touch with the reality the writer had in mind before writing the text. Poor readers are often too dependent on the written form and cannot relate what they read to their own concepts about reality. Thus, identifying the meaning relation may help them in reading comprehension and, for example, summary writing. (Kauppinen and Laurinen 1986:31.)

However, although the meaning relations model is not dependent on the written form of texts, the analyses

carried out in this study show that both Kauppinen and Laurinen's model and Hoey's models take the structure and content of texts into account. In the analysis of <u>Fresh Green Engineers</u> the meaning relations model reflects the generalization structure (p.35) of the text. This conclusion is based on the fact that the most important information in the diagram is centered on the main concept and its characteristics. Similarly, in a generalization text structure there is always a main idea and most of the other sentences either clarify or extend this main idea. The information included in the same space with the main concept of <u>FGE</u> can be said to clarify and extend the main concept. In other words, the defining and explaining relations considered to be the most important in <u>FGE</u> seem to correspond to the generalization structure of the text.

Further, it may be true that the meaning relations model is not as clearly dependent on structural features such as signalling or the ordering of ideas in a text as Hoey's model is, but most readers/analysts utilize these kinds of markers when conducting the analysis – whether they are conscious of it or not. Thus, to be able to understand and apply the meaning relations analysis one has to be aware of both the structure and the content of the text. Similarly, the Problem-Solution pattern cannot be analysed unless the reader has understood both what is said in the text, that is, the content and the organization of the text. Furthermore, it seems that the definitions of concepts such as 'text structure' and 'content' and the relationship between them are largely dependent on the researcher in question.

Moreover, it seems that Kauppinen and Laurinen's meaning relations model is not as well defined and unambiguous as Hoey's Problem-Solution model. The meaning relations model does not offer such clear and practical clues for application as Hoey's model does and is largely based on how the reader has understood the text, that is, on intuition. In this study Kauppinen and Laurinen's model is used to analyse the text <u>Fresh Green Engineers</u> because the text does not have a very clear structure

and, therefore, a model that is based more on content
than structural signal seems more easily applicable.
Hoey's Problem-Solution pattern analysis, in turn,
applies well to the text <u>Reproducing Copying Machines</u>
since the text has a clear structure and it can be
analysed with the help of various explicit and implicit
signalling elements. Therefore, it seems that although
Kauppinen and Laurinen's model is not very well defined
and clear, it can be applied to a greater variety of
texts, even ill-structured texts, whereas Hoey's model
applies only to texts with a clear Problem-Solution
structure.

Obviously, in the end, both models of analysis
are based on the analyst's intuition. (S)he is ultimately
the one who makes the decisions concerning how to apply
the model and this decision-making cannot be but partly
subjective. Thus, there is no such thing as a completely
objective text analysis model.

The models of text analysis presented above will
be used when analyzing the students' summaries in regard
of sensitivity to text structure in section **4.5** below
(p.65). In the following section, however, the inclusion
of the main points of the original texts in the summaries
is analyzed.

4.4 Main points in the students' summaries

The importance of including the main points and deleting
the trivial information in a summary was discussed in the
Theoretical Background section (p.20-21). For example
Winograd (1984:404) argues that sensitivity to importance
is related to the ability to produce summaries and to
comprehend what has been read. Moreover, it has been
found that good readers are more sensitive to important
information and include more main propositions in their
summaries than poor readers (Winograd 1984:410; Johns
1985:501). The age of the students is of importance as
well; college and high school students outperform younger
students in their ability to identify important
information (Brown, Day and Jones 1983:977). However,

Sherrard (1989:1) states that although selecting the main points is a central summarizing strategy it is also the least understood strategy and quite difficult to teach.

In the present study the main points of the original texts are identified on the basis of the expert summaries (Appendixes III-IV). A corresponding procedure is used, for example, in the studies by Winograd (1984), Johns (1985) and Stotesbury (1991). According to the two expert summaries, then, the main points of the text Reproducing Copying Machines are the following:

1) A serious environmental problem is created by dumped copying machines

2) Several manufacturers have started to take their old machines back

3) The copying machines are either reused or recycled

4) Parts of the copying machines can be reused as well

5) The companies have taken measures to increase the return rates

6) These procedures are not really useful unless the machines are designed so that recycling and reusing is possible

7) The copying machines should be designed for disassembly and have the same basic structure

8) These efforts produce economical savings as well as environmental benefits

Thus, the main points above are selected on the basis of the information included in the expert summaries of RCM (Appendix III). However, the two expert summaries are not identical and as a result the selecting process was not always unambiguous. Where the expert summaries differ, compromises are made about the information which should be included in the main points. These kinds of differences between the expert summaries are, however, minor and quite rare.

The summaries written by the students of the text RCM were then checked for the main points above.

Some difficulties occurred in this process as well. First of all, it was sometimes difficult to decide whether a certain main point was included in the summary or not because the information was expressed so differently in the student's summary than in the expert summary. However, if the information could be concluded to correspond to the information in the main point, even though the wording differed, the main point was noted to be present in the summary. Secondly, in some of the main points information has been combined so that one main point may include more than one proposition. In the students' summaries, however, it was allowed that these propositions were presented separately. In other words, when checking the students' summaries for the main points, it did not matter in what form or in what way the information was presented as long as it could be concluded that it was found in the summary.

The main points found in the students' summaries are shown in Table 1 below.

Table 1

Main points in the summaries of the text Reproducing copying machines.

SUMMARIES	MAIN POINTS							
	1	2	3	4	5	6	7	8
1	x	x	x	x		x	x	x
2		x	x	x		x	(x)	x
3	x	x	x	x	x	(x)	x	x
4	x	x	x	x			(x)	x
5	x	x	x	x			(x)	(x)
6		x	x		(x)	x	x	(x)
7	x	x	x	x		(x)	(x)	x
8	x	x	x	x		(x)	x	x
9	x						(x)	x
10	x	x	x	x			(x)	x
11	x	x	x	x	x	x	(x)	(x)

In the table the students' summaries are placed vertically on the left hand side and numbered. The main points, in turn, are placed horizontally. The table is interpreted so that if a certain main point is present in a certain summary, an 'x' is placed underneath it. For example, summary 1 includes the main points 1, 2, 3, 4,

6, 7 and 8. Some of the x's are enclosed in brackets to show that only part of the main point can be found in the summary. For example, there are a lot brackets in the column of main point 7. The reason for this is that, as can be seen above, in main point 7 information is combined; it is said that environmental efforts produce economical savings **and** environmental benefits. Many students included only one of these ideas in their summaries and left out the other one.

When looking at Table 1 it can be noticed that main point 5 is not included in the majority of the summaries. This main point conveys the information that the copying machine companies have taken measures to increase the return rates of the machines and their parts. Apparently many of the students have not considered this information important enough to be included in a summary. Another explanation for the absence of main point 5 may be that the information included in it is found at the end of the third paragraph in RCM. It is possible that many students have ignored this information because they have concentrated on the first sentences of the paragraph. Further, the sentences preceeding main point 5 include a lot of detailed information about the different kinds of parts of copying machines which can be returned. The details may have confused some students and made them skip the end of the paragraph without reading it properly. After all, the time for the summarizing task was only 45 minutes and for some it might not have been enough in order to perform efficiently.

Another main point with which some students seemed to have problems was main point 6. It was present in four summaries and partly present in three. The information included in main point 6 concerns the limited utility of the environmental efforts described in the text and some measures taken by the companies to improve this utility. In this case the main point is found in the beginning of the fourth paragraph and therefore the explanation offered above about the position is not acceptable. However, in the summaries where main point 6

is only partly present, that is, summaries 3, 7 and 8 the problem seems to be that the efforts described earlier in the text **are not useful** unless some additional measures are taken. Thus, it seems that it was difficult for some students to recoqnize this turning point in the text. Similarly, it seems that the students who left out main point 5 completely had the same problem. These students did not seem to realize that it would have been important to explain in the summary **why** the additional environmental efforts are needed and what is their relationship with the efforts presented earlier.

The other main points seem to have been recoqnized quite well by the students. The summaries including the most main points are summaries 3 and 11 (Appendix I). The summary with the fewest main points, in turn, is summary 9 (Appendix I). There are other problems with summary 9 as well. First of all, it is rather short, and as a result a lot of essential information is missing. However, although the summary is short it still includes some trivial information, for example percentages. Secondly, it seems that the writer of summary 9 has either misunderstood the original text or simply used a wrong verb ('increase' instead of 'decrease') in the summary by accident. As a result of this misunderstanding or error the meaning of the summary is in fact opposite to that of the original text. In other words, summary 9 distorts the meaning of RCM to a great extent. On the basis of the analysis of summary 9 it seems to be true that the ability to identify main points is related to the ability to produce summaries and to reading comprehension, as Winograd (1984) argues.

All in all, the students seem to have recoqnized the main points in RCM rather well when compared to the expert summaries. Almost all the summaries include main points 1, 2, 3, 4, 7 and 8, at least partly.

However, the case is not quite the same with the text Fresh Green Engineers. Before presenting the table of the main points in the summaries, however, the main points have to be established. As with RCM, the main points were selected on the basis of the two expert

summaries written of the text (Appendix IV). This time the selecting process was, even with the help of the expert summaries, more difficult than with RCM because of the degree of difficulty and complexity of the text. The difficulties are discussed in more detail below. Nevertheless, the following main points were selected from FGE:

1)Engineering education has not traditionally addressed environmental issues

2)The Georgia Institute of Technology has started a new engineering curriculum which teaches engineers to consider environmental issues

3)The program aims at changing engineering students from problem solvers to problem formulators

4)Another aim is to teach engineering students integrative skills

5)A third aim is to provide the students with different types of analytical tools

6)The program is interdisciplinary: experts from the field of engineering as well cognitive science and public policy take part in it

7)Three courses are already being taught in the program

8)The ultimate aim of the program is that everyone graduating from the Institute will have basic knowledge of sustainable development

It is obvious that the main points of FGE are longer and more complex than those of RCM. This is due to the fact that, as mentioned above, the text FGE is more difficult and complex than RCM. A lot of information is included in the text and it is presented so that it is not easy to identify the most important points. This also shows in the amount of main points included in the students' summaries. Although the summaries were analysed in the same way as with RCM, that is, the form and wording of the important information presented were allowed to vary,

less main points were identified of FGE than of RCM. This can be seen Table 2 below.

Table 2

Main points in the summaries of the text Fresh green engineers.

SUMMARIES	MAIN POINTS							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	x	x	x	x		(x)	(x)	
2		x		(x)	x		x	x
3	x	x		(x)		(x)	x	x
4	(x)		x		x		x	x
5		x	x	(x)		x	x	x
6	x	x	x				x	x
7		x	x	x		x	x	
8	(x)						(x)	
9	(x)	x		x			x	x
10	x	x	x	x	(x)		x	

According to Table 2, main point 5 is the one included in the fewest cases in the students' summaries. The information included in this main point describes the third aim of the engineering curriculum, that is, providing the engineering students with different types of analytical tools. The absence of main point 5 in many summaries may be due to the fact that it is not presented in the text with the other aims. Further, it is not clearly indicated in the text that acquiring analytical tools is one of the aims of the program. The other aims of the program, the ultimate aim excluded, are given the second and third paragraphs and all the information in these paragraphs in basically about the aims. However, the beginning of the fourth paragraph where main point 5 is presented is about how the curriculum functions. Thus it is possible that most of the students were not able to identify the aim in this paragraph. To be able to construct a summary of a text one has to realize that important information could be found anywhere in the text, especially with complex texts (Pincus, Geller and Stover 1986:156).

In contrast, it is more difficult to find an explanation to the fact that main point 6 is absent in most of the summaries as well. This main point includes

information about the interdisciplinary nature of the engineering curriculum and gives some examples of the fields represented in it. This information is presented in the beginning of the fourth paragraph in the text. Thus main points 5 and 6 are found in the same paragraph and this naturally arises the question whether the fourth paragraph was somehow totally ignored by some of the students. On the other hand, there are only three summaries where both main point 5 and main point 6 are excluded (summaries 6, 8 and 9). In summary 6 information from the fourth paragraph is present but in summaries 8 and 9 this paragraph is totally ignored. However, this explanation does not seem to be sufficient for most of the summaries. Another reason for the lack of main point 6 could be that the fourth paragraph includes quite a long list of the different fields represented in the curriculum. If not reading carefully, one could simply ignore this part of the text on the basis of the knowledge that lists of examples are not usually included in a summary. However, as mentioned above, when writing a summary one should read the entire text carefully and expect important information to be found in various parts of the text. Naturally, the problem of insufficient time may be the explanation as well – as in all cases described here.

Less main points were included in summaries of FGE than in summaries of RCM. There are, however, four summaries in which only two main points are missing, summaries 1, 3, 5 and 10, although in all of them at least one main point is included only partly (summaries 5 and 10 can be found in Appendix II). Nevertheless, considering the complexity of the text these students can be said to have performed well. The summary including the fewest main points, in turn, is summary 8 (Appendix II). There are only two main points present there and, what is more, both of them are present only partly. When examining summary 8 it seems to be quite obvious that the writer has not understood the original text very well or has not been able to write a summary of it in English. Almost nothing of the new engineering program is

mentioned in the summary. For example, it is said that the change in engineers' habits will help them solve their problems but it is not explained what kinds of habits should change, how they should change and what kinds of problems would be solved. All this information is crucial in summarizing FGE. On the other hand, it seems that the writer was in a hurry since (s)he has not finished the summary. Nevertheless, the analysis of summary 8 can be said to prove Winograd's claim about the interrelatedness of the ability to identify important information, summarizing skills and reading comprehension, as did the analysis of summary 9 of RCM above (p.56).

4.5 Sensitivity to text structure in the students' summaries

Another aspect of the students' summaries discussed in the present study is their sensitivity to the structure of the original text. It was shown above (p.21) that a good summary should be connected to the original text and should follow its structure. Moreover, researchers have found that students who write the best summaries seem to be able to identify the structure of the original text and to follow it in their summaries. (Golden, Haslett and Gauntt 1988:144-150). Further, it has been found that instruction of text structure helps students to identify the main points of a problem-solution text structure and to organize and integrate their summaries efficiently (Armbuster, Anderson and Ostertag 1987:343-344).

Expository text structures tend to be more difficult for students to comprehend than narrative text structures. However, it is expository texts that are used in school and in professional life and thus students need to be able to read and understand them. (Golden, Haslett and Gauntt 1988:139). Both the texts used in this study are unmodified expository texts. The texts RCM and FGE are naturally occurring texts taken from the subjects' course material and are, as a result, not as well-structured or easy to read as modified texts could be.

However, RCM and FGE are texts the students will have to deal with in school and in professional life and that is why it is important to find out how they cope with them and their structures.

4.5.1 Sensitivity to the structure of Reproducing Copying Machines

The structure of RCM was analysed in detail on pages 37–47 and for the purposes of summary analysis the most important elements of the structures were chosen. Thus, on the basis of Hoey's (1983) structure analysis, the most important elements of the Problem–Solution structure of RCM seem to be **Situation** (sentence (1)), **Problem** (sentence (2)), **Response 1** (sentence (4)), **Response 2** (sentence (9)), **Response 3** (clause (13b)), **Response 4** (sentence (17)), **Result/Evaluation combined** (sentence (12), **Negative Evaluation** (clause (13a)) and **Positive Evaluation** (sentence (20)). After establishing the above elements the students' summaries were checked for the inclusion of the elements, that is, for their sensitivity to the Problem–Solution structure of RCM. In other words, inclusion of the most important elements of the Problem–Solution structure in the students' summaries was used to determine the degree of their sensitivity to the structure and whether or not it could be concluded that they had recoqnized the structure. The results of the structure analysis of summaries written of RCM are presented in Table 3 below.

Table 3

The main elements of the problem-solution structure in the summaries of Reproducing copying machines.

THE MAIN ELEMENTS OF THE PROBLEM-SOLUTION STRUCTURE									
Summaries	Situation	Problem	Responses				Result/ evaluation combined	Negative evaluation	Positive evaluation
			1	2	3	4			
1		X	X	X	X	X		X	X
2			X	X	X				X
3	X		X	X	X	X	X	X	X
4			X	X	X		X		X
5		X	X	X	X				X
6	X		X		X	X		X	
7	X	X	X	X	X	X			X
8	X	X	X	X	X	X			X
9	X	X			X				X
10	X	X	X	X	X	X			X
11	X	X	X	X	X		X	X	X
E$_1$	X	X	X	X	X		X	X	X
E$_2$	X	X	X	X	X	X		X	X

As in Tables 1 and 2 above, in Table 3 the students summaries are placed vertically on the left hand side and the main elements of the Problem–Solution structure horizontally. The two expert summaries are present in the table as well (E1 and E2). In Table 3, as with Tables 1 and 2, an 'x' is marked below a certain main element if a summary can be concluded to include that element. For example, summary 1 includes the main elements **Problem, Responses 1-4, Negative Evaluation** and **Positive Evaluation.**

There were some problems in the process of checking the summaries for the main elements of the Problem–Solution structure. These problems have to do mainly with the presentation of information in the students' summaries as compared to the original text. In some cases it was rather ambiguous whether or not it could be concluded that a certain element was present in a summary. This was the case with, for example, the **Problem** element. Some summaries include information about the dumped copying machines but do not state clearly that this is a problem and it is because of this problem that some other ways of dealing with the old machines have to be created. In these cases it was concluded that the main

element **Problem** was not present in the summary. This is because the **Problem** element is crucial in the Problem-Solution structure and is, in fact, the starting point of the entire text. In order to convey the structure in a summary properly the **Problem** has to be stated clearly.

Another difficulty in the analysis of the summaries emerged with the main element **Negative Evaluation**. The element consists of information included in clause (13a) and this information is about the limited utility and expensiveness of the recycling measures unless the products are designed keeping recycling in mind. In some summaries only part of the **Negative Evaluation** element is mentioned, either limited utility or expensiveness. Nevertheless, in these cases it was decided that **Negative Evaluation** was present and an 'x' was marked underneath it. The decicion is based on the fact that although only part of the information forming the element was present in the summaries, the students seemed to have recoqnized the purpose and importance of the element. The purpose of **Negative Evaluation** in the text is to introduce a new problem and, as a result, new responses have to be presented. This purpose is conveyed in a summary even though only part of the **Negative Evaluation** information is included. After all, in the analysis concerning sensitivity to text structure it is not really the amount of information present in the summary that counts but the way in which the information is presented, that is, whether or not it can be said that the writer has recoqnized the function of a certain structural element.

When looking at Table 3, it can be seen that the main element **Result/Evaluation combined** is the one least included in the summaries. It is absent even in expert summary 2. The main element **Result/Evaluation combined** consists of the information presented in sentence (12) in RCM, that is, information about what the copying machine companies have done to increase the return rates of copying machine parts. Indeed, it may be argued that perhaps this element of the Problem-Solution structure is not as crucial in the text as some of the other elements.

At least it does not seem to be justified to say that if the **Result/Evaluation combined** element is not present in a summary, the writer has not recoqnized the structure of the text. However, the same cannot be said about the absence of the **Negative Evaluation** element. This element is present in only four of the students' summaries and in both expert summaries. Even students who have otherwise included several other elements in their summaries have failed to include the **Negative Evaluation** element (summaries 7, 8 and 10). In contrast to the **Result/Evaluation** element, the **Negative Evaluation** element seems to be of importance in the Problem—Solution structure of RCM. This is because, as mentioned above, **Negative Evaluation** presents a new problem in a Problem—Solution text and causes the need to offer new responses as well. In the cases of summaries 7, 8 and 10, however, it seems justified to say that, although the writers have not recoqnized the introduction of a new problem, they still have recoqnized the overall structure of the text. This conclusion is based on the fact that all the other elements are present in these summaries except **Negative Evaluation** and **Result/Evaluation combined**. Therefore, the writers of summaries 7, 8 and 10 have recoqnized the overall Problem—Solution structure of the RCM. The performance of the writer of summary 5 is a little weaker because, in addition to **Negative Evaluation**, also the main elements of **Situation**, **Response 4** and **Result/Evaluation combined** are missing. Nevertheless, it may be argued that also this writer has recoqnized the Problem—Solution structure of the original text at least to some extent because (s)he has included the **Problem**, **Responses 1-3** and **Positive Evaluation** in the summary. Obviously, the performance is still inadequate and it cannot be said for certain that the writer of summary 5 has understood the structure of RCM.

However, the situation seems to be even worse with the summaries 2, 4 and 9. Not only have the writers of these summaries left out many of the main elements of the Problem—Solution structure but they have also left out some of the most important elements. The most crucial

element the writers of summaries 2 and 4 have failed to include is the **Problem** and, what is more, the **Situation** is absent as well. Thus, summaries 2 and 4 begin directly with the **Responses** and fail to provide the reader with the reason for these **Responses**. As a result, the Problem–Solution structure of <u>RCM</u> is not conveyed in these summaries. The writer of summary 9 (Appendix I), in contrast, presents the elements **Situation** and **Problem** in the summary but fails to produce most of the **Responses**, including the crucial **Response 1**. In other words, in summary 9 the reader is given the situation in the beginning, which clearly requires some solutions, but only one of these solutions is actually presented in the summary. Thus, it can be concluded that the writer of summary 9 has failed to recognize the Problem–Solution structure of <u>RCM</u> as well. There are also other serious problems in summary 9, as mentioned above in the main point analysis. On the basis of the structure analysis and main point analysis of summary 9 it seems to be true that sensitivity to text structure helps students to identify the main points in a Problem–Solution text, as Armbuster, Anderson and Ostertag (1987:343) argue.

Further, there are two other summaries which do not seem to be following the Problem–Solution structure of <u>RCM</u>. These are summaries 3 and 6. In summary 6, the most important elements that are absent are the **Problem** and **Positive Evaluation**. As already mentioned, the main element **Problem** is crucial in the Problem–Solution structure because without it there the reader is not given any reason for the actions described in the text. Moreover, the writer of summary 6 has left out **Positive Evaluation**, which means that the **Responses** presented in the summary are not evaluated positively in the end as they are in the original text. The absence of these two crucial elements in summary 6 proves that the writer has not recognized the Problem–Solution structure of <u>RCM</u>. In the case of summary 3 (Appendix I), however, the decision about the writer's sensitivity to text structure is not as unambiguous. Interestingly, the writer of summary 3 has included all the other main elements of the Problem–

Solution structure except the most important one, the **Problem**. The absence of the element **Problem** in a summary of a Problem-Solution text seems to indicate that the writer has not recoqnized the structure of the original text. However, the writer of summary 3 does provide the reader with the **Situation** in the beginning and also hints at the **Problem**, implying that 4 million copiers ending up in dumps every year is not a good thing. On the basis of these facts it may be concluded that the writer of summary 3 probably has recognized the Problem-Solution structure of RCM.

In conclusion, it seems that the writers of summaries 2, 4, 6 and 9 have not recoqnized the Problem-Solution structure of the original text RCM. This may be because they do not know that such a structure exists and is common in English or because they simply cannot apply their knowledge about text structures in practice. However, the writers of the other summaries seem to have recoqnized, at least partly, the structure of the original text. Apart from the expert summaries, summary 11 (Appendix I) can be said to be the most proficient when it comes to following the Problem-Solution structure of RCM. It is difficult to say whether these writers actually consciously thought about the Problem-Solution text structure when reading and writing or recoqnized and followed it without knowing that they were doing so. However, the results indicate that six out of eleven students recoqnized the Problem-Solution text structure, one recoqnized it to some extent and four failed to recoqnize the structure.

4.5.2 Sensitivity to the structure of Fresh Green Engineers

The structure of FGE has already been defined as that of generalization and the main elements of this structure were selected on the basis of the meaning relations analysis by Kauppinen and Laurinen (1984, 1986) (pp.50-55). On the basis of the meaning relations analysis the main elements of the generalization structure of FGE are

main concept, forms of expression 1-2, ways of functioning, aims 1-4 and effective factors. The information contained in these main elements are presented in the meaning relations diagram of FGE found on page 52. As with the text RCM, the students' summaries of FGE were checked for the main elements. The results of this checking process are illustrated in Table 4 below.

Table 4

Meaning relations in the summaries of Fresh green engineers.

Summaries	Main concept	Forms of expression		Ways of functioning	Aims				Effective factors	
		1	2		1	2	3	4	1	2
1	x	x	x	x	x	x	x			x
2	x	x	x		x			x		
3	x	x	x	x	x			x		x
4		x	x			x		x		
5	x	x	x	x	x	x		x		
6	x	x	x		x	x		x		
7	x	x	x	x		x	x		x	
8			x						x	
9	x	x	x		x		x	x	. x	
10	x	x	x		x		x			
E₁	x	x	x	x	x	x		x		x
E₂	x	x		x	x	x	x	x		x

Table 4 is interpreted in the same way as Table 3 above. Ten students were present in the class at this data collecting time and as a result there are ten summaries written by the students in the table and the two expert summaries.

As with the text RCM, some difficult decisions concerning the method of analysis the summaries had to be made with FGE as well. One such decision has to do with the crucial main element **main concept**. The **main concept** of FGE is sustainable development as a part of engineering education. The two summaries that do not have an 'x' underneath the **main concept** in the table do contain some information about a new way of thinking in engineering education but they do not clearly connect

sustainable development with the education. Since the **main concept** can be said to be the most important element in <u>FGE</u> and all the other information in the text is connected to it the decision was made that in order to get an 'x' in the table this information has to be clearly present in the summaries. Thus, it may be that the writers of summaries 4 and 8 had understood the **main concept** of <u>FGE</u> but had failed to reproduce the information in their summaries.

The main meaning relation **aim 3** caused problems in the analysis process of the summaries as well. This meaning relation consists of the information that one aim of the engineering curriculum is to address the fact that engineers lack integrative skills. In the meaning relations diagram (p.52) underneath **aim 3** there are some case examples of it, including, for example, engineers' lack of understanding the entire design process and engineers' lack of understanding issues in global context. However, only the information about the integrative skills was expected to be found in the students' summaries, information about the case examples was not considered to be adequate or necessary. Some of the writers have included information about the case examples of **aim 3** in their summaries or have written simply that the engineering curriculum aims to address problems in engineering education in general. In both cases the information was considered to be inadequate when checking the summaries, in the first case it is too detailed and in the second case too general. Thus, it was decided that these summaries do not include the main meaning relation **aim 3**.

When examining Table 4, it can be seen that both the **effective factors** are absent in most of the summaries. These meaning relations contain information that either improve or hinder the existence of the **main concept**, that is, the new engineering education program. **Effective factor 1** deals with the information which concerns the funding of the program and **effective factor 2**, in turn, includes information about the traditional way of thinking in engineering education, which may

hinder the development of curricula combining engineering education and sustainable development. However, it may be argued that this information is not as crucial in the structure of FGE as the information included in the meaning relations which directly define the **main concept**. This argument is based on the fact that, although both the improving and hindering factors seem to affect the **main concept** directly, they are only briefly mentioned in the text and their effects are not discussed in detail. In other words, despite the fact that the **effective factors** are mentioned in the text, the text is not actually about them or their influence on the education program. Rather, the text FGE concentrates on describing the **main concept** and its qualities. Thus, it may be concluded that although many writers, including the expert writers, have left out both or one of the **effective factors**, this alone probably does not mean that they have not been sensitive to the generalization structure of FGE.

Most of the writers have included in their summaries the most crucial meaning relations the **main concept** and **forms of expression** 1. Without the information included in these meaning relations the summary is not really a summary of the text FGE and the writer of the summary has clearly not recoqnized the structure of the original text. There are two summaries in which the **main concept** is missing, summaries 4 and 8. There are also many other meaning relations missing in these summaries, especially in summary 8 (Appendix II). In summary 8 the only meaning relations which are present are **forms of expression 2** and **effective factor 1**. The information included in these meaning relations consists of the facts that there are three courses in the education program now and that the program is funded. It is clear that this information is not enough and that the writer of summary 8 has not recoqnized the generalization structure of FGE. The performance of this writer was poor in the main point analysis as well and these findings seem to prove, once again, that Armbuster, Anderson and Ostertag (1987:343) are right in their argument that

recoqnizing the text structure facilitates identification of the main points when writing a summary. The writer of summary 4, however, has included four meaning relations in his/her summary, including **forms of expression 1**, which contains the fact that a new engineering education program has begun at the Georgia Institute of Technology. Summary 4 also includes two of the **aims** of the program. The problem with this summary is, however, that the writer does not connect the concept of sustainable development to the engineering curriculum until the end of the summary. Since the idea of sustainable development is central in <u>FGE</u> and included in the **main concept** as well, it should be presented clearly in the beginning of the summary. On the basis of this argument and the fact that most of the other meaning relations are missing as well it can be said that the writer of summary 4 has not recoqnized the structure of <u>FGE</u> either.

Table 4 shows that many students had problems with the meaning relations **ways of functioning** and **aims 1-4** as well. It seems that the information contained in **ways of functioning**, that is, the fact that the education program is interdisciplinary and includes teachers from various fields, is rather important in the <u>FGE</u>. This feature of the education program is explained in the text in length and seems to be one of its key ideas. In addition to summaries 4 and 8, which have already been analysed above, the meaning relation **ways of functioning** is missing in summaries 2, 6, 9 and 10 (summary 10 can be found in Appendix II). It is doubtful whether these writers have recognized the structure of <u>FGE</u>, at least if two of the **aims** are missing as well, as in summaries 2 and 10. In summaries 6 and 9 three of the **aims** are included, and despite the absence of **ways of functioning**, it can be said that they follow the structure of <u>FGE</u> to some extent. Further, the writers of summaries 3 and 7 have included **ways of functioning** and two of the **aims** in their summaries. They, too, can be said to have followed the structure of the original text to some extent.

There are not many students who seem to have really recoqnized the generalization structure of <u>FGE</u> and

followed it in their summaries. On the basis of Table 4 the summaries in which most of the important meaning relations are present are summaries 1 and 5 (summary 5 can be found in Appendix II). It is not surprising that the two expert summaries seem to follow the structure of the original text closely. In summary of the results of Table 4, then, two of the students' summaries and the expert summaries follow the structure of FGE, four summaries follow it to some extent and four summaries do not follow it at all.

When comparing the results presented in Table 3 and Table 4, it seems that the students had more difficulties with the generalization structure of FGE than with the Problem-Solution structure of RCM. Moreover, the writers of the two expert summaries failed to include two of the main structural elements of FGE in their summaries, whereas with RCM they both missed only one element. As already mentioned, the structure of FGE is not very clear and there is a lot of information in it which is, in some places, presented in a confusing way. For example, the aims of the education program are scattered all over the text and the author does not signal the different elements of the structure clearly. The structure of RCM, in turn, is rather straightforward and the different structural elements are often signalled. The complexity of FGE as compared to RCM shows in the main point analysis as well. Table 1 and Table 2 indicate that the students identified more main points in RCM than in FGE. Therefore, it seems that a clear text structure which is signalled by the author and which students can recognize facilitates the identification of the most important information in a summary.

It is important to point out that the main point analysis and the structural analysis of the students' summaries are different. First of all, although there are similarities in the information contained in the main points and in the main structural elements of the texts, not all the information is the same. As can be seen when comparing the main points and the main structural elements, some of the information contained in them

differs. Moreover, there were differences in the processes of analysis of the summaries. In the main point analysis the summaries were checked for the information only, it did not matter in what way the information was presented or what words were used. However, in the structural analysis the way in which the structural elements were presented in the summaries was, at least in some cases, very important. For example, when determining whether or not a student had included the main element **Problem** in the summary the most important criterion was that the information was clearly presented as a problem. Moreover, in a summary of <u>FGE</u>, the **main concept** was expected to be presented so that the engineering education program and the idea of sustainable development were clearly connected to each other.

DISCUSSION AND CONCLUSION

In this study the summarizing skills of Finnish engineering students were analysed as to the ability to identify the main points in the original texts and to the sensitivity to the structures of the original texts. The findings show, first of all, that the students who included several main points in their summaries also wrote otherwise competent summaries. Correspondingly, summaries which lacked many main points also contained other problems, such as incoherence and distortions. This finding seems to support Winograd's (1984) claim that sensitivity to importance is related to the ability to produce written summaries.

Another finding revealed in the main point analysis of the summaries was that many students had difficulties identifying them if they were located in unexpected places. For example, some main points were located at the end of a paragraph or were preceeded in text by information describing unimportant details. In these cases many students seemed to have problems in recognizing the main points. Pincus, Geller and Stover (1986) argue that if students are faced with unfamiliar text structures they do not have schemata for, they may

have difficulties in identifying the main points in the text. Lacking schemata for the new structure, they try to apply their existing knowledge about text structures, and this often leads to an unsatisfactory result. The students do not know where to look for important information in a new structure and thus miss the main points. The engineering students in the present study probably suffered from this lack of schemata.

Therefore, knowledge of and sensitivity to text structures seem to facilitate the identification of important information in the summary writing process. Meyer (1985) argues that in expository texts the structure determines the logical connections between ideas and reveals the subordination of some ideas to others. Golden, Haslett and Gauntt (1988) found that skilled readers are usually more aware of text structures than poor readers and, as a result, better able to identify the important information in texts. Moreover, according to Armbuster, Anderson and Ostertag (1987) instruction of structure helps students to identify main points in texts. These findings seem to be confirmed by the results of the present study, since the students who did not recoqnize the structures of the original texts also missed several main points, whereas the summaries that followed the structures of the original texts included most of the main points.

In addition to the ability to identify main points, recoqnizing the text structure also improves the quality of the summary otherwise. In this study the students who did not recoqnize the structures of the original texts wrote summaries of otherwise poor quality as well. Armbuster, Anderson and Ostertag (1987) found that structure instruction helped their subjects to organize and integrate their summaries efficiently. Further, Golden, Haslett and Gauntt (1988) argue that recoqnition of text structure facilitates the production of summaries. This conclusion seems to be supported by the findings of the present study.

Furthermore, Hare, Rabinowitz and Schieble (1989) state that students have more difficulties in

identifying the main ideas in ill-structured texts than in texts with a clear structure. Similarly, Kintsch and van Dijk (1978) argue that a complex text slows down the comprehension process and makes it more difficult. In the present study, the structure of the text Fresh Green Engineers seemed to be more difficult for the students than the structure of Reproducing Copying Machines. The students' summary writing performance was poorer with FGE regarding both the identification of main points and recognition of text structure. Indeed, the structure of FGE seemed to be more complex and unclear than the structure of RCM, as one of the writers of the expert summaries commented. The complexity of FGE apparently resulted in summaries of poorer quality than summaries of RCM. Thus, complexity of the input text structure seems to affect summary writing and the quality of summaries.

Researchers have found differences in performance when comparing ESL students and native speaker students, and summarizing in L1 and L2. For example, Johns and Mayes (1990) point out that, compared to native speaker students, ESL students may not have enough knowledge about the conventional rhetorical structures used in English texts and are thus not able to recognize them. It is probable that some of the students in the present study suffered from this lack of knowledge. In both summarization tasks there seemed to be at least one student who did not recognize the structure of the original text at all and ignored it in his/her summary. The lack of schemata influenced on the number of main points in the summary and its overall quality as well.

Summarization task requires more than comprehension; it requires also the abilities to condense ideas and to produce a written summary. For ESL students the production phase of summary writing is at least as important as the comprehension phase because they have to write in a foreign language (Johns and Mayes 1990). Thus, problems in the ESL students' summarizing process may not always be due to comprehension difficulties but writing difficulties. The engineering students in the present

study summarized texts of their own field of study which were part of their course material. As a result, it seems justified to assume that they were familiar with the subject matter and vocabulary of the texts at least to some extent, although syntactic structures may have caused some problems. Nevertheless, given the familiarity of the subject it is probable that it was text production rather than comprehension that was the source of many problems, or, even more likely, both of them together. This conclusion is supported by the fact that the students used a lot of direct copying in their summaries. Thus, it seems that due to problems in text production, they simply copied information from the original text. Direct copying is typical in the summaries of ESL students when summarizing in English (Johns and Mayes 1990; Stotesbury 1991) and in the summaries of young native speaker children (Brown, Day and Jones 1983).

The summarizing skills of Finnish university students have been studied by, for example, Pitkänen-Huhta (1996) and Stotesbury (1991). Pitkänen-Huhta did not find any specific differences between performances in L1 and L2 but this is probably partly due to the fact that her subjects were students of English and thus fairly competent in the language. Stotesbury, however, found that Finnish history students used almost twice as many direct quotes in their L2 summaries than in L1 summaries when summarizing an English text. As mentioned above, copying directly from the original text was a problem in the present study as well. Moreover, when compared to subject specialists, Stotesbury's subjects included more details in their summaries. In the present study, too, some students included too many details in their summaries, sometimes instead of main points and sometimes in addition to them. Therefore, the Finnish engineering students seemed to have similar difficulties in summary writing as the history students in Stotesbury's study.

On the basis of the findings described above it seems that there is a need for more instruction of text structures and analysis in Finnish schools. Obviously,

the number of subjects in the present study is very small and the results cannot be assumed to apply to all Finnish students. Nevertheless, on the basis of the present data and data obtained in earlier studies of ESL students, it is justified to say that L2 students would benefit from instruction of English text structures in schools. Further, from my own experience I know that not much text analysis is done in Finnish schools, at least not with L2 texts. Summarizing and the ability to identify the most important information is essential in all studying and in professional life because of the vast amount of information available nowadays. Further, more and more of this information to be dealt with and studied is in foreign languages, most of all English.

Familiarizing students with a variety of text structures used in Finnish and L2 texts helps them to become aware of the differences between them and their characteristics as well as to find the important information in them. As a result, students would have existing schemata for several structures and would not be overwhelmed with unfamiliar material later on. Knowledge of text structures facilitates text production as well. Reading and analysing various L1 and L2 texts can improve students' own writing because they could apply their knowledge about conventional ways of organizing information to it. Thus writing, especially in L2, would become easier and more organized. It would probably be necessary to begin with the instruction of text structures even before university because it is during the first years of academic education that students are likely to face a lot of difficult and unfamiliar material, often written in foreign languages. Moreover, it is nowadays possible to include a summary writing task in the matriculation examination in Finnish upper secondary schools (Kauppinen and Laurinen 1994; Stotesbury 1991). With more knowledge about different text structures students would be better prepared for the task.

In addition to the aspects of summary writing on which this study has concentrated on, it would be

interesting to find out what the students themselves think about summary writing and text structures. Students could be asked what, in their opinion, a good summary is like, whether they find the task difficult, and whether they consider it important. Moreover, questions about text structure could include asking the students to define text structure and to name some structures they know. They could also be shown texts and asked to name or describe their structures. This way it would be possible to find out whether knowledge about and sensitivity to text structures is something conscious or whether people simply apply their knowledge unconsciously. The answer to this question would certainly be helpful when seeking to improve second language education and instruction of text structures.

Finally, Finnish students' summarizing skills could be studied further with different types of texts concentrating on aspects not considered in this study. For example, it seems that Finnish students, like other ESL students, have a tendency to copy directly from the original text when summarizing in English and to include too many details in their summaries. It would be useful to study these aspects more and try to find out, for example, what kind of information is copied directly and whether the copying takes place primarily because of comprehension or production problems, and what kind of details are included in the summaries and why. Furthermore, the effect of instruction of text structures and summary writing on Finnish students needs to be studied in order to know what kind of instruction is the most useful to different groups of students.

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APPENDIX I: EXAMPLES OF THE STUDENTS' SUMMARIES OF
<u>REPRODUCING COPYING MACHINES</u>

Summary 3

Every year 4 million copiers reach the end of their useful lives. Instead of hauling them out to the dump, several manufacturers are now taking back their old machines.

The devices are taken apart, the components are sorted and anything salvageable is sent back to the factory. Unsuitable materials for remanufacturing are recycled. It's estimated that 95 percent of a returned copier can be somehow reused leaving only 5 percent as carbage. Nonserviceable parts are recycled as well, if possible. Incentives and discounts from manufacturers have resulted in a return rate on some items or parts of 60 percent. This isn't possible unless products are designed with these operations in engineers' minds. For example, formerly a machine contained 100 kinds of plastics, now the count is 25 and the goal in the future is 5 to 10. Some other goals are design for disassembly and interchangeability of parts.

Almost any time environmental benefits produce savings and economic advantage.

158 words

Summary 9

Many million copiers are reaching their useful lifespan every year. They create a very big amount of waste.

We can increase the waste amount using recycling. It is estimated that with recycling materials 5 percent of 100 percent can be used again.

Engineers are designing products that are recyclable. They try to create machines that are made of less parts. They are also designing a new structure for

machines so that products will use the same basic structure.

Longer life span will increase waste amount in the future.

The purer environment the less costs. The savings are many million dollars a year for companies.

105 words

Summary 11

Every year some 4 million copiers reach the end of their useful lives. They are just dumped and the waste is becoming a very serious problem. Several manufacturers will now take back their old machines. The devices are taken apart and components are cleaned. Every useful part is sent back to remanufacturing process. Other unsuitable materials are recycled.

It's estimated that 60 percent of a returned copier can be reused while only 5 percent is left as carbage.

Incentives and discounts from the company have resulted in a return rate of 60%. Products have to be designed this return idea in mind. Otherwise it's expensive.

For example in Xerox, engineers are encouraged to design products using recyclable or recycled materials. Preference is avoiding waste at the outset.

Aim is at producing parts containing the same material and designing products that use the same basic structure. These kinds of efforts will produce savings.

150 words

APPENDIX II: EXAMPLES OF THE STUDENTS' SUMMARIES OF <u>FRESH GREEN ENGINEERS</u>

Summary 5

At the Georgia Institute of Technology there is going on an ambitious effort to educate engineers who regard the environmental costs of their activities. The program tries to teach the students to become leaders in formulating the problems. The other aim is to expand the students' thinking and understanding more global.

The team responsible includes engineers of every field and representatives from cognitive science and public policy.

There have been three courses already and the audience isn't limited to engineering students. The dean of the institute ensures that by the end of the project all graduated are exposed to the concepts of sustainable development and technology.

106 words

Summary 8

The text Fresh Green Engineers is about a new way of thinking. Education is the most important thing if we want to get really effective results.

One project funded by GE Fund and another foundation was made in order to get better engineers.

Due to the project they hope that engineers' habits will change. The change will help them solve their problems. The program helps them also to find lacks in education in general.

Vanegas says that engineering students need more skills to assess risks and impacts. There are already courses teaching the audience sustainable development. Vanegas says that they try to penetrate the curriculum in context. All who graduate from Georgia Tech are...

Summary 10

Engineers are educated to understand sustainable development. Their way of thinking is changed so that environmental costs are included to their activities. Such education must start in engineering school like it has at the Georgia Institute of Technology.

The program tries to change engineers' habit of reacting to a problem and seeking to solve it. Integrative skills and global problem understanding are developed.

Engineering students need to perform life-cycle analyses and solve technical problems taking into account economic, sociopolitical, and environmental factors. Three courses are already being taught in the program. The goal of the project is to penetrate the curriculum in context.

103 words

APPENDIX III: EXPERT SUMMARIES OF <u>REPRODUCING COPYING</u>
<u>MACHINES</u>

Expert summary 1

The fact that about 4 million 'dead' copying machines are
thrown away every year has clearly become an
environmental problem. To avoid this problem several
manufacturers, eg. Xerox, have started taking back their
old machines and reusing salvageable parts and recycling
unsuitable ones. Also unserviceable parts like toner
cartridges can now be returned. Xerox even gives
incentives and discounts to those who return these items
which has resulted in about 60% return of these parts.

However, to be really useful, this requires that
products with reusable components are designed, which
Xerox has started doing. Important is also that products
using the same basic structure will be designed. These
efforts will save money, in addition to the environmental
benefits.

118 words

Expert summary 2

Every year, about four million copying machines are
dumped. Producers have, however, taken measures to avoid
the huge amount of waste. Several manufacturers have
started to take their own machines back. The returned
components are either remanufactured after cleaning or
recycled if they are unsuitable for remanufacturing.
Nonserviceable parts as well as toner cartridges and
bottles are also brought back and put to use again. Many
companies have paid attention to increasing the return
and recycle rates, but procedures to attain this is
expensive. Moreover, more attention should be paid on
designing products so that recycling and remanufacturing
are possible. This includes design for disassembly and

common basic structures to enchance interchangeability. However, protecting nature is also profitable to the companies as taking environmental measures usually produces savings.

128 words

APPENDIX IV: EXPERT SUMMARIES OF <u>FRESH GREEN ENGINEERS</u>

Expert summary 1

An important way to further sustainable development is by educating engineers to think in a new way, because they have traditionally not been taught to consider the environmental costs of their activities. In the Georgia Institute of Technology this has led to the design of a curriculum that teaches future engineers to take sustainable development into consideration in their work. The basic idea in the program is to teach the future engineers to formulate problems and to understand issues in a global context. The program is interdisciplinary, including representatives of varying fields from engineering to cognitive science and public policy. The idea is that engineering students need different types of analytical tools. Three courses are already being taught in the program, which according to its founder aims at ensuring that all engineers graduating from the Institute have been exposed to the ideas of sustainability.

144 words

Expert summary 2

Traditionally, engineering education has not addressed environmental issues. The Georgia Institute of Technology in Atlanta has, however, started an ambitious effort of educating engineers for a new way of thinking. The aim of this engineering curriculum is to change engineers from problem solvers to problem formulators. The program also focuses on what are perceived as problems with engineering education, such as the lack of integrative skills. The effort is multidisciplinary including representatives from fields such as mechanical and chemical engineering as well as cognitive science and public policy. Experts in educational and multimedia

technology and in the cognition of learning are also involved in developing the curriculum. The ultimate aim is to make sure that everyone graduating from this program will gain basic knowledge of the concepts of sustainable development and technology

132 words