

WRITING MATHEMATICS THROUGH DOMINANT DISCOURSES: THE CASE OF A GREEK SCHOOL MATHEMATICS MAGAZINE

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In the present article, we examine the use of ‘traditional’ and ‘progressive’ discourses in a Greek school mathematics magazine (Euclid A). The analysis indicates that Euclid A seems to draw on both traditional and progressive discourses in order to write mathematics for his/her readers. However, the prevailing lexicogrammatical features are mostly connected with traditional rather than progressive discourse. This means that the general background against which the two discourses are articulated in the textual corpus is that of traditional discourse. From a critical discourse analysis perspective, the ‘progressive’ discourse enacted in Euclid A functions ideologically: far from ensuring equitable access to school mathematics, it creates confusion. Thus, being subjugated by the dominant traditional discourse, ‘progressive’ discourse perpetuates the established order in school mathematics.

DOMINANT DISCOURSES IN MATHEMATICS EDUCATION

The traditional/progressive dipole is a cherished one in mathematics education, which reflects two *contrasting*, and at the same time *dominant*, conceptions or ‘myths’ (Dowling, 1998) about the way school mathematics is (or *is not*) organized around issues of ‘classification’ and ‘framing’ (Bernstein, 1990) [1]. According to the ‘traditional’ view, mathematical knowledge transmitted in school needs to follow the logic of academic mathematics (strong classification), while teacher constitutes the ‘guardian of science’ (Hanrahan, 2006) and possesses absolute control over his/her communication with students (strong framing). According to the ‘progressive’ view, school mathematics must be connected with the life experience of students (weak classification), while the role of teacher is to facilitate the learning process, and therefore students are given selections for knowledge reception (weak framing).

Traditional discourse has been strongly criticized for limiting the access of students, and especially those from working and lower social class backgrounds, to mathematics, treating science as ‘a special truth that only the superintelligent few can understand’ (Lemke, 1990, p. 149). Hence, diverse alternative projects have been developed in an attempt to renew the school mathematics curriculum in many countries, such as the ‘Realistic Mathematics Curriculum’ developed in IOWO,

Netherlands (Treffers, 1987), the movement of ‘ethnomathematics’ in Africa and Brazil (Gerdes, 1996) and the ‘Common Sense Activities’ of the Genova group in Italy (Bussi, 1996). Far from being homogeneous, these projects could be broadly characterized as adopting a ‘progressive’ perspective, in the sense that they share a common concern for the growing number of students failing in mathematics, and therefore for attempting to relate mathematics to real world experiences (for a further discussion see Chronaki, 2000).

Nevertheless, research on mathematical texts, especially from a sociological approach (e.g. Apple, 2000; Dowling, 1998), points out that mathematical texts, whether they draw on a ‘traditional’ or ‘progressive’ discourse, they reproduce an ideal cosmos. On the one hand, traditional discourse tends to mythologize the innate powers of mathematical knowledge. On the other hand, by recontextualizing everyday experience into pedagogic context, progressive discourse oversimplifies and exoticizes social reality. In a similar vein, Walkerdine (1998) comments that ‘traditional’ and ‘progressive’ are two ‘common-sense’ categories that do not really exist but are in fact socially constructed and serve the politics of the time. Consequently, it seems more important to pay attention on the type of use one makes of ‘traditional’ and ‘progressive’ than on the labels themselves.

In the present article, we examine the use of ‘traditional’ and ‘progressive’ discourses in a Greek school mathematics magazine (*Euclid A*). In the present context, ‘traditional’ and ‘progressive’ constructs are not employed in the sense of evaluating mathematical texts as ‘good’ (using progressive discourse) or ‘bad’ (using traditional discourse), but as analytic units for exploring contrasting ways of representing mathematics. Adopting a Critical Discourse Analysis perspective (CDA: e.g. Fairclough & Wodak, 1997; Van Dijk, 1993), the aim of our study is to examine whether ‘traditional’ discourse contributes to social continuity (non-equitable access to school mathematics) and whether ‘progressive’ discourse contributes to social change (equitable access to school mathematics). Moreover, seeing discourse in the light of ideology, Critical Discourse Analysis allows a study of whether and to what extent traditional discourse naturalizes the ‘science’ of mathematics and subjugates progressive discourse. The analysis of the two discourses is made with the use of the analytic framework of Systemic Functional Grammar of Halliday (1994) and is situated within the context of similar studies conducted in mathematics (Morgan, 1998) and science education texts (Dimopoulos et al., 2005; Hanrahan, 2006; Knain, 2001).

EUCLID A: A SCHOOL MATHEMATICS MAGAZINE

Euclid A is an official magazine of the Hellenic Mathematical Society (HMS) and aims to familiarise students in late primary and early secondary school with

mathematics. Its editorial board mostly comprises experienced secondary maths teachers who are, at the same time, authors of articles appearing in the magazine. Although, one witnesses changes in the editorial board over the years, a small number of people consists a stable core. The status of *Euclid A* as a school mathematics magazine is constructed around the fact that a) it is distributed through the HMS at a very low price in almost all schools of the country (and thus it becomes visible and available), and b) its content aims not only to support and extend school mathematics but also to train the gifted ones for entry in the maths Olympiads.

The content of text is structured around areas such as theoretical extensions of mathematical concepts (e.g. symmetry, multiplication, polygons), activities (e.g. problems to solve, open problems, exercises), real life problems, general interest and the students' own voice, where they could send their answers to specific problems.

CRITICAL DISCOURSE ANALYSIS

Critical Discourse Analysis (CDA; e.g. Fairclough, 1992; Fairclough & Wodak, 1997; Van Dijk, 1993) is a sociolinguistic/sociosemiotic approach that acknowledges the central role that language/semiosis occupies in the social life of late modernity (Chouliaraki & Fairclough, 1999). In particular, CDA attempts to bridge linguistic with social analyses of texts, focusing on both the linguistic features of texts and the social structures underpinning those texts [2]. The combination of linguistic with social analysis is achieved through a focus on discursive practice (e.g. the formation of discourse), which is seen as the intersection of linguistic (i.e. text) and social processes (i.e. social practice). Texts are seen as the sites where elements of contrasting discursive practices struggle for dominance over each other. This 'movement' leads to various mixtures of discursive practices within texts, called 'interdiscursivity' (Fairclough, 1992).

Due to its Western Marxist origins, CDA supports the view that language is dialectically related to society. It also puts an emphasis on the ideological role of discourse in perpetuating and legitimizing the dominant representations of the world, through which relations of power are maintained. In particular, CDA is 'critical' in the sense that it unveils naturalized and 'common sense' versions of the world that support the status quo as well as 'hegemonic' worldviews that subjugate and appropriate any alternative to the established order representations of reality.

SYSTEMIC FUNCTIONAL GRAMMAR

Systemic Functional Grammar (Halliday, 1994) is a lexico-grammatical theory which does not consider language to be a self-contained system, and thus to function in a vacuum and independently of the context in which it is embedded. Instead, it

attempts to explain how language serves the aims and intentions of the speaker/writer, depending on the way it is used each time. From this perspective, language is seen as a network of options from which language users make selections that are ideologically significant. Moreover, language is regarded as being multi-functional, namely, as performing simultaneously an 'ideational' (talk about a specific subject matter), an 'interpersonal' (interact with the hearer/ reader) and a 'textual' (construct the medium of communication) function. Halliday has developed a toolkit for the analysis of these three functions of language, connecting them with specific lexicogrammatical features. For the purposes of the analysis presented below, we focus here in the description of the tools of *vocabulary* and *transitivity* (ideational function), as well as of *personal deixis* and *speech acts* (interpersonal function).

Analysis of ideational function

Language users construct images of social reality by drawing mostly upon selections of vocabulary and transitivity (Fairclough, 1992). Vocabulary provides labels, namely, gives existence to elements of experience, since an object or idea does not exist without the word that describes it. In this sense, vocabulary organizes the world (Fowler, 1991). At the same time, the 'lexicalization' (Fairclough, 1992) of social reality and the structure of the world that it offers shapes a specific version and image of social reality.

Language users do not only interpret reality by naming it through vocabulary, but also by defining it in terms of causality (i.e. 'who does what to whom'). This happens, according to Halliday (1994), via the system of 'transitivity'. Specifically, we give causal meaning to the world through language by determining 'processes' and 'participants'. In order to determine the nature of processes, Halliday (1994) distinguishes among 'material' (doing), 'mental' (sensing), 'relational' (being) and 'verbal' (saying) processes, based on the way processes are worded [3]. Relational processes are further distinguished into 'attributive' (e.g. 'the exercise is difficult') and 'identifying' (e.g. 'the triangle is isosceles'). For the determination of causality, namely, for the determination of the way participants are linked to processes, a distinction is drawn between participants that initiate processes, the 'agents' ('who does') and participants that receive processes, 'the affected' ('to whom something is done').

Analysis of interpersonal function

'Personal deixis' is part of the broader linguistic phenomenon of 'deixis', which refers to the forms of language used to link a text with the time (the 'now': temporal deixis) and place (the 'here': spatial deixis) of communication, as well as with the

participants, the writer and the reader ('me' and 'you': personal deixis) (Fowler, 1991). Hence, personal deixis, in particular, involves all allusions made in a text to the writer and/or reader, which is mainly expressed through the selection of person (i.e. 1st, 2nd and 3rd person of singular or plural number) in personal (e.g. I, we, you) and possessive pronouns (e.g. my, our, your).

'Speech acts' give a view of language as a tool through which language user expresses his/her intentions and acts (Austin, 1962; Searle, 1969). There are five types of speech acts performed through language. In our data, we found two of them: 'assertive', through which speakers/writers express their belief towards a state of affairs (state, inform) and 'directive', through which speakers/writers ask addressee to do something (request, recommend). Thus, speech acts assume specific writer/speaker and reader/hearer positions. Assertive speech acts are oriented to the writer/speaker himself/herself, while the role of the reader/hearer is that of someone being told. Conversely, directive acts are highly interactional in character, being oriented to the reader/hearer, whose role is that of someone being asked for something. For the purposes of the present analysis, four major types of directives were distinguished, according to the degree of power held by the participants of interaction: 'requests' (e.g. 'Find the factor and the main part of the following monomials') and 'instructions' (e.g. 'In each rectangle parallelogram, we draw a diagonal and we observe that it divides the shape in two equal rectangle triangles'), which assume authority on the part of writer, 'questions', which entail less power on the part of writer (e.g. 'How do we find this number?'), and 'suggestions', which assume relevant equality between writer and reader (e.g. 'Thus, we can use various simple geometrical shapes').

The sociolinguistic profile of traditional and progressive discourses

Drawing upon the work of Morgan (1998) on mathematical texts and upon the studies of Dimopoulos et al. (2005), Hanrahan (2006) and Knain (2001) about science education texts, we sketched the sociolinguistic profile of traditional and progressive discourses, and thus we were able to identify the two discourses in the articles of *Euclid A*.

Specifically, traditional discourse, as a recontextualized discourse of science, has many of the characteristics of dominant academic discourse, which promotes a positivist view of the world and experience, such as the elimination of any external (to the described world, e.g. human) agency (mathematics as initiator of processes), the adoption of an impersonal style with no interaction between writer and reader (absence of personal deixis), the formulation of definitions and classifications (technical vocabulary, relational identifying processes), and a focus on the transmission of knowledge (assertive speech acts). Moreover, the teacher as

transmitter of scientific knowledge has control over the pedagogic process in relation to students (teacher as agent of material processes, second person singular and plural, directive acts of requesting and instructing).

In its attempt to be more familiar and accessible to students, progressive discourse draws on sociolinguistic features from their primary discourse (non-technical and colloquial vocabulary, material processes). An emphasis is also put on human agency and subjective description (humans as agent of material, mental and verbal processes, relational attributive processes, first person of singular number), as well as on the negotiation of mathematics with students (third person of singular and plural number, first person of plural number, directive acts of suggesting).

WRITING MATHEMATICS IN *EUCLID A*

The results from the analysis of the whole textual corpus (Stamou & Chronaki, in preparation) suggest that the texts are interdiscursive, exhibiting features that refer to both discourses. However, the prevailing lexico-grammatical features are mostly connected with traditional rather than progressive discourse. This means that the general background against which the two discourses are articulated in the textual corpus is that of traditional discourse. This has important consequences for the way progressive discourse is textually enacted.

In order to illustrate the way the discourses are interwoven together in the texts, we focus on the analysis of two largely heterogeneous texts but which have a different orientation. Text A mainly draws on traditional discourse, whereas text B has a more progressive perspective. Because articles were four to five pages long, we decided to present some representative extracts of each article in terms of the different styles they employ. We kept all typographic (e.g. bold) and punctuation (e.g. full stops) conventions of the originals.

Analysis of Text A

In this text, three distinct styles were drawn upon, which are clearly distinguished from each other with headings. The text begins with Style 1 (for illustration, see extract 1), which represents 20% of the text's length, followed by Style 2 (see extract 2), which occupies 35% of the text [4]. Finally, Style 3 (see extract 3) is drawn upon, representing 45% of the text's length.

In terms of transitivity, in Style 1, both relational identifying processes initiated by mathematics as well as mental and material processes performed by human agency are employed. Conversely, in Styles 2 and 3, there are only material processes performed by human agents. This stress on human agency has different

premises. In Style 2, it is used to describe the work of famous mathematicians, whereas, in Style 3, in order to describe the work of students (reader) in a pedagogic context. Regarding vocabulary, Styles 1 and 3 are very technical, containing many terms from mathematics. The writers seem to be preoccupied with introducing the specialized vocabulary to readers by using bold fonts (this is a practice used extensively throughout the article). It is noteworthy that even Style 2, which does not contain technical words, is treated like such, with the use of bold fonts for the names of famous mathematicians. In interpersonal meanings, Style 1 and 3 are interactional, whereas Style 2 is completely impersonal. Specifically, Style 1 employs the first person plural 'we' to refer to both writers and reader. The speech acts performed are most of them directive and there are few assertive. Directive acts are instructions. Style 2 has no reference to personal deixis, while the speech acts performed are assertive. Style 3 is a traditional pedagogic one: the interaction is constructed on the basis of authority on the part of writers over reader, with the use of the second person plural 'you' to refer to reader and the performance of directive acts of requesting [5].

In conclusion, the text uses three distinct styles (for a summary, see Table 1 in the Appendix), but these do not make the text look contradictory. Each style has a specific place in the text and all of them gather lexico-grammatical features that mainly relate to traditional discourse. There are some exceptions, which are not, however, disconnected from the whole. Although mental processes are typical characteristics of progressive discourse, in the present context, they are rather linked to traditional one. In particular, the specific mental process used (i.e. 'suppose' in contrast to the pedagogic mental 'observe' or 'see') is commonly used in academic mathematics, in which case, the reader is addressed as a thinker and invited to join the authors and institute a common world (Morgan, 1998). On the other hand, because of the specific context, the first person plural 'we' employed is rather ambiguous in its interpretation: it could be construed as a reader-inclusive pedagogic 'we' (progressive discourse), but also as a reader-exclusive academic 'we' (traditional discourse).

Text A

Style 1 'A problem'

...We can suppose that the fraction a/b is **improper** (i.e. that its terms have no other common divisor than unit), because if it is not improper we can always make it improper by simplification. We suppose that the numbers a and b are prime between them (i.e. G.C.M. $(a, b) = 1$ and G.C.M. $(3^2, 5^2) = 1$, since a common divisor of $3^2 = 9$ and $5^2 = 25$ must be common divisor also of 3 and 5)...We concluded to 'reductio ad absurdum' because we accepted that the equation (1) has solution a rational number. Thus, we conclude that such rational number does not exist. In other words, the measure of hypotenuse of rectangular triangle ABC is not a rational number.

Style 2 'From the history of irrational numbers'

The non-real numbers (irrational numbers) were discovered by the School that the philosopher **Pythagoras** from the island of Samos established in Krotonas of South Italy in the 6th century B.C. It is told that the student of Pythagoras, **Ippassos**, discovered them...The asymmetric magnitudes became known, and the great mathematician of antiquity **Eudoxos** made a theory that founds the ratios and the analogies between any similar magnitudes (symmetric or asymmetric). This theory was included in '**Elements of Euclid**'.

Style 3 'Exercises that we propose'

- Find the numerical value of algebraic representation:

$$5z^4y^4o^5/2x^3, \text{ if } x=1, y=-1, o=2, z=-2$$

- Find the final form (i.e. the form that results from operations and reductions of same terms) of the following representation:

$$(x-1)(x-2) + (x-2)(x-3) + (x-2)(x-8)$$

- Determine the l , so that the polynomial: x^3+2x+l , be perfectly divided with $(x-2)$.

Analysis of Text B

In this text, four distinct styles were drawn upon. Styles were not distinguished from each other in a consistent way [6]. The text begins with an alternation between Style 1 (23% the text's length) and 2 (31% of the text). Then, Style 3 is drawn upon (24% of the text). Next, there is a frame, in which Style 2 is again employed for a while, and finally Style 4 is drawn upon (22% of the text), signaled by a heading.

In terms of transitivity, all extracts refer to human agency. In Style 1, human agency stands for the writer, who mainly initiates mental processes in order to describe his personal perceptions of mathematics. In Style 2, human agency is represented by a famous mathematician, who performs material processes for the description of his work. In Style 3, the human agent is generic (i.e. writer, reader, whoever), who initiates material processes for the making of calculations in an unspecified context (it could be pedagogic, domestic etc.). In Style 4, human agency is represented by the reader-student, who performs material processes for the description of mathematical operations in a pedagogic context. Regarding vocabulary, Style 2, 3 and 4 involve semi-technical words, whereas Style 1 contains colloquial lexis. In interpersonal meanings, Styles 1, 3 and 4 are interactional, whereas Style 2 is completely impersonal. Specifically, Style 1 is written in first person singular by referring to writer, and thus it adopts a highly personal style. The speech acts performed are assertive, which is linked to the narrative character of the Style. Style 2 does not make any reference to personal deixis, while the speech acts performed are assertive. Style 3 constitutes a mixture of traditional and progressive pedagogic style: the writer exerts his power over his reader by performing directive

acts of instructing. However, the use of the third person singular 'one/ he' attenuates his authority, by speaking in generic terms, and thus it is a more negotiable style, echoing progressive discourse. Finally, Style 4 represents a traditional pedagogic style: the interaction is constructed on the basis of authority on the part of writer over reader, with the use of the second person singular 'you' to refer to reader and the performance of directive acts of requesting.

In conclusion, like text A, text B also uses distinct styles (for a summary, see Table 2 in the Appendix). Contrary to text A, though, in which the distinct lexicogrammatical features form a coherent whole, in text B, they seem to create discontinuity. In fact, the writer seems indecisive between traditional and progressive discourse. At the beginning of the text, he alternates between them (Style 1 and Style 2), whereas, next, he adopts a mixture of the two discourses (Style 3), concluding to traditional discourse (Style 4). Moreover, some of the contrasting elements represent 'marginal cases' in respect to the whole textual corpus analyzed (Stamou & Chronaki, in preparation). Thus, the highly personalized Style 1, which refers to progressive discourse, was rarely used in general. On the other hand, the authoritative stance of writer over reader of Style 4, and especially the use of second person singular (and not plural), being part of traditional pedagogic style, was also rarely employed in the corpus. Finally, the intimacy created between writer and reader by Style 1 at the beginning of the text, which strikes the reader, because it is not a common stylistic option in *Euclid A*, is cancelled by the prevailing traditional discourse in the rest of the text (Style 2, Style 4 and Style 3 in part). Furthermore, this highly personalized style seems to be actually exploited for the use of a highly authoritative style (Style 4), which could be easier accepted, because it has gained the reader's trust, having being offered in a 'progressive' wrapping.

Text B

Style 1 Turning over the pages of the school textbook of Informatics, my eyes caught a picture. In its subtitle, I read that it is about Napier rods...It was the first time that I heard of Napier rods. I did not understand much from the picture, and the text did not explain much on them either. How were they and how were they used? Because they drew my interest, I decided to search about them.

Style 2 The machine of Schickard is considered to be the first calculator and was constructed between 1620 and 1623, in an attempt to automate astronomic calculations. For the construction of his machine, Schickard, who was professor in the university, relied on the so-called Napier rods... In 1614, the Scot J. Napier constructed a series of rods with which he could make easily and simply calculations. For example, he could make the most difficult multiplication into a simple addition.

Style 3 If one had to multiply 456×2 , he should take the rods of 4, 5 and 6 and put them the one next to the other in this order. Next, he should consult the second row in which the multiples of each number (4, 5, 6) were written and should add the numbers he found which

were written diagonally...If, on the other hand, he had to find the product 456×52 , then he should write 52 as a sum of tens and its units, that is, $52 = 50 + 2$. Next, he should find in the rods the product 456×5 and add up to this a zero (5 tens).

Style 4 'And now it's your turn'

Make rods like these of Napier with paper or with the rods of ice cream and use them to make various multiplications. Execute the multiplication 268×34 , first with the Napier rods and then with the method of Arabs. Verify the result by executing the multiplication with the manner you know...Place the digits 1, 4, 6, 8, 9 in squares and find the highest and the lowest product.

CONCLUDING REMARKS

Euclid A seems to draw on both traditional and progressive discourses in order to write mathematics for his/her readers. However, the prevailing lexico-grammatical features are mostly connected with traditional rather than progressive discourse. This means that the general background against which the two discourses are articulated in the textual corpus is that of traditional discourse. Therefore, even texts that have a more progressive orientation necessarily also draw on features of traditional discourse, resulting in the formation of contradictory and discontinuous texts. From a critical discourse analysis perspective, the 'progressive' discourse enacted in *Euclid A* functions ideologically: far from ensuring equitable access to school mathematics, it creates confusion. Thus, being subjugated by the dominant traditional discourse, 'progressive' discourse perpetuates the established order in school mathematics.

NOTES

1. 'Classification' determines the epistemological relationship between systems of knowledge. In the present context, the systems of knowledge are specialized scientific knowledge vs. everyday common sense knowledge. Strong classification assumes well-defined boundaries between them, whereas weak classification assumes blurred borderlines between them. 'Framing', on the other hand, refers to the way power roles between teacher and pupils are shaped during pedagogic interaction. Strong framing means that the pedagogic control belongs clearly to teacher, whereas weak framing means that students are left room for negotiation over the learning process.
2. The notion of 'text' is interpreted very broadly within CDA, referring to any instance of communication, oral (e.g. classroom talk), written (e.g. newspaper article), linguistic, visual (e.g. picture) and multi-modal (e.g. advertisement). Therefore, although CDA has a linguistic tradition, it could not be characterized as a strictly 'sociolinguistic' approach, but rather as a 'sociosemiotic' one (Hodge & Kress, 1988). However, because the present analysis focuses on language, we talk only about 'linguistic' analysis.

3. In the framework of mathematics that we study, processes such as 'add', 'calculate' and 'measure', despite being of intellectual nature, following Morgan (1998), they are treated as material rather as mental processes. Specifically, Morgan maintains that such processes give the impression that mathematics concern 'doing' certain things, namely, manipulating numbers, symbols and shapes. In contrast, mental are processes like 'think', 'conclude' and 'suppose', which give the impression that mathematics concern 'sensing' certain things.
4. This was estimated with respect to the lines each style occupied in relation to the whole text.
5. In Greek the distinction between the second person of singular and that of plural number is grammatically signalled.
6. The transition of one style to the other was signalled with italics, with frames, with headings or with no sign at all.

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APPENDIX

Table 1. Summary of the lexico-grammatical features of text A

	Transitivity	Vocabulary	Personal deixis	Speech acts
Style 1	Relational identifying processes initiated by mathematics, mental and material processes performed by human agency	Technical (bold fonts)	First person plural 'we'	Directive (instructions) and few assertive
Style 2	Material processes performed by human agency	Treated as technical (bold fonts)	No personal deixis	Assertive
Style 3	Material processes performed by human agency	Technical	Second person plural 'you'	Directive (requests)

Table 2. Summary of the lexico-grammatical features of text B

Stamou and Chronaki. 2007. Writing mathematics through dominant discourses: the case of a Greek school magazine. In D. Pitta-Pantazi and G. Philippou (eds). Proceedings of the 5th Congress of the European Society for Research in Mathematics Education. 22-26 Fe, 2007. Nicosia Cyprus

	Transitivity	Vocabulary	Personal deixis	Speech acts
Style 1	Mental and few material processes performed by human agency	Colloquial	First person singular 'I'	Assertive
Style 2	Material processes performed by human agency	Semi-technical	No personal deixis	Assertive
Style 3	Material processes performed by human agency	Semi-technical	Third person singular 'one/he'	Directive (instructions)
Style 4	Material processes performed by human agency	Semi-technical	Second person singular 'you'	Directive (requests)