

Project Title: Digital applications for teaching reading and narrative skills in multilingual Greek primary school classes

Project Logo:

D_Read-Narrate
Digital READING & NARRATION for BILINGUALS



Subject: WP2 Specification of Smart Games educational content

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1. EXECUTIVE SUMMARY

This deliverable describes the rationale and procedure followed for the selection and development of the application's linguistic domain models, which will support the design of the Smart Games to be used with bilingual and monolingual primary school children. Given the focus of the project, the application's domain models target and assess a broad range of linguistic knowledge, skills and features that go beyond phoneme or word recognition, including morphological, morphosyntactic and syntactic features that are relevant to the processing and production of larger pieces of language.

The selection of the language categories and specific features that were included in the domain models is based on the results of extensive literature research, frequency counts from children's books and corpora available in Greek, as well as empirical data. The models of the D_Read-Narrate project were initially based on the models developed for the iRead project (targeting beginning readers and students with dyslexia), however they underwent revisions so that they would serve the purposes of the current project. Additionally, the development of the domain models involved the categorization of the language features into levels of difficulty, which indicate the degree of difficulty/complexity of each feature in comparison to the other features within the same category, and the calculation of progression schemes in the form of prerequisites, which indicate the order in which these features should be presented in classroom activities.

This report is organized as follows: Chapter 2 introduces the development of the domain models and presents the two steps of the relevant process: step 1, that is the analysis and selection of language material, and step 2 which refers to the relative ranking of features in terms of difficulty. Chapter 3 analyzes the general methodological steps followed in the development and selection of the pedagogical activities and smart games which were designed to practice these language features.

2. ANALYSIS AND SELECTION OF LANGUAGE MATERIALS

The main goal of this WP was to develop the Smart Games component of D_Read-Narrate. To this end, based on relevant second language (L2)/ bilingualism literature, we proceeded with refining and adapting the existing iRead domain model by selecting language categories and features based on the needs of the target populations of the current project. Specifically, we developed two different domain models, one for bilingual and one for monolingual students. The domain models involved the same language categories and features, yet the level of difficulty was differentiated between the two, depending on the linguistic profile of the users (i.e. Greek as L1 or L2). Crucially, the two models are also different with respect to the thresholds that will regulate the progression of the students along the different activities/ smart games and language areas. Typically developing monolingual children progress more easily across activities targeting phonology to morphology and syntax in the development of reading skills. In contrast, the progression schemes for bilingual learners differ because their initial linguistic knowledge is more limited compared to L1 readers (Grabe, 2009).

2.1.Steps followed

Building on the findings of the iRead project, we developed our domain models by refining and updating the existing phonological, morphological and syntactic classifications. In the D_Read-Narrate models, the language domains/areas that were used from the iRead models were phonology, morphology and syntax, while particular categories and features were added or removed according to the focus of the present project. This process involved two important steps: (a) the selection of language categories and features and (b) the determination of the relative difficulty of the features within each category, based on the relevant literature.

2.1.1. Selecting language categories and features

In order to reliably select the appropriate linguistic phenomena for the new models, we first used evidence from relevant studies on the populations targeted. Specifically, we conducted extensive literature reviews not only to define the relevant language areas for grammatical skills and reading development, but also to define which language areas are harder to develop while learning to read or while acquiring a second language.

Based on the work of Varlokosta and Triantafyllidou (2011) and the CEFR (2018) for Greek, which targets language development in L2 Greek, we found that some features included in the textbooks were not included in the original iRead domain models and were therefore added in the reviewed syntactic content of the current project's domain models (see Appendix 1 for added features).

After completing the necessary modifications in the iRead educational content (iRead Project (2018). Deliverables 4.1, 4.2), we concluded in a final set of 289 features at the linguistic levels of phonology, morphology and syntax. These linguistic levels are divided into different language categories, e.g. grapheme-phoneme correspondence in phonology, prefixes, inflectional and derivational suffixes in morphology, function words (e.g., articles, prepositions etc.), embedding (i.e. complement, adverbial, conditional and relative clauses), discourse anaphors and voice (i.e. non-active forms in passive, reflexive, reciprocal and deponent verbs) in syntax. Table 1 presents the distribution of language features by category and linguistic level.

Linguistic Level	Language Category	N of Features
Phonology	Grapheme-phoneme correspondence	64
Morphology	Prefixes	13
	Suffixes: Inflectional	80
	Suffixes: Derivational	47
Syntax	Function words	41
	Embedding	26
	Discourse anaphors	3
	Voice (active, non-active)	15

Table 1: Number of features in the domain models by language category and linguistic level.

2.1.2. Defining difficulty

Within each language category, the features were ordered according to their level of difficulty and complexity. For example, each of the two domain models in the D_Read-Narrate project includes the same features in Greek (phonological, morphological and syntactic), taking into account the challenges that these properties may pose to students' language development. Therefore, within each category, simpler and less complex structures are introduced first, followed by more advanced structures. For example, *-os* noun suffixes (e.g. suffixes in the noun *anthropos* (man)) are introduced before *-ous* noun suffixes (e.g. suffixes in the noun *alepous* (genitive)). This progression is guided by setting learning prerequisites for each feature (see Table 2 below). A prerequisite for a particular feature refers to the linguistic elements that must have been acquired, either within the same category or from related categories, so that the targeted feature can be practiced through the Smart Games. The concept of 'complexity' is not only relevant for bilingual students but also applies to monolingual students, who may also have difficulties with certain linguistic structures and therefore need to practice them. In order to define which linguistic features are easier or more difficult for students, previous findings from the relevant L1 and L2 literature and the results of the iRead project (iRead Project (2018). Deliverables 4.1, 4.2) were studied. For example, genitive plural inflectional suffixes (*-on*, as in *anthrop-on*) were marked as difficulty level 1 for monolinguals, but difficulty level 3 for bilinguals (see also Tables 2 and 3 below).

The set difficulty levels were stored in the domain models and play a crucial role in guiding students' reading progress by outlining the typical learning progression. The model takes into account both the difficulty levels of the features within each category and the necessary prerequisites for acquiring new knowledge. The linguistic level of phonology is the first linguistic level to be introduced to students, while morphology follows and syntax is the final linguistic level presented. The difficulty level of a feature determines its prerequisites, so that all prerequisite features within a category have the same or lower difficulty level yet are never more advanced than the next category. For example, a child learning to read Greek must first master the feature *tr* (pronounced /tr/) in phonology, which has difficulty level 1 for L1 or 2 for L2, before they can move on to the more complex feature *ntr* (as in *antras*, pronounced /dr/), which has difficulty level 3 for L1 or 4 for L2. Another example comes from morphology: *-atos* noun suffixes (e.g. genitive: *kreatos* (flesh)), although marked as difficulty 4 for L2, are a prerequisite for complement clauses in syntax introduced by *oti* (e.g. *O adras pistevi oti ton athliti filise i jineka* (The man believes that the athlete was kissed by the woman)) and have difficulty 1 for L2. This structured approach was employed in the development of Smart Games and in the organization of language features/ categories in digital activities by arranging the features to match the student's learning progression.

As regards the number of levels of difficulty, four (4) levels were set within each category, so as to ensure simplicity in the design of the Smart Games and establish smooth progression from one category/feature to the next, so that students can have the opportunity to practice as many language properties as possible. Additionally, it is important to note that children learning L2 do not progress at the same pace as typical monolingual novice readers. For language progression to be achieved in L2, students need to have input and practice complex language, which is achieved through the

progression scheme designed. As you can see in Tables 2 and 3, there are two different schemes for the two domain models (L1 Domain Model, L2 Domain Model). The Tables show which pair (Linguistic level + Difficulty level) is a prerequisite for which, as well as the correct response thresholds for progression. For example, Morphology 1 is a prerequisite for Syntax 1. In the L1 Domain Model, Syntax 1 activities are available only when the student has been presented with at least 40 questions in Morphology 1 with a minimum correct response threshold of 80%. If the success rate in Morphology 1 falls below 70%, Syntax 1 is locked, until success rate rises back to 60%.

Prerequisite		To		Unlocks next		Locks Next
Linguistic Level	Difficulty	Linguistic Level	Difficulty	Number of Questions	Correct Answers Percentage	Correct Answers Percentage
Phonology	1	Phonology	2	30	60%	50%
Phonology	1	Phonology	3	60	80%	60%
Phonology	2	Phonology	3	30	60%	50%
Phonology	2	Phonology	4	60	80%	60%
Phonology	3	Phonology	4	30	60%	50%
Phonology	1	Morphology	1	40	80%	70%
Phonology	2	Morphology	1	20	60%	50%
Phonology	3	Morphology	2	60	80%	70%
Morphology	1	Morphology	2	30	60%	50%
Phonology	4	Morphology	3	60	80%	70%
Morphology	1	Morphology	3	60	70%	60%
Morphology	2	Morphology	3	30	60%	50%
Morphology	2	Morphology	4	60	80%	60%
Morphology	3	Morphology	4	30	60%	50%
Morphology	1	Syntax	1	40	80%	70%
Morphology	2	Syntax	1	20	60%	50%
Morphology	3	Syntax	2	60	80%	70%
Syntax	1	Syntax	2	30	60%	50%
Morphology	4	Syntax	3	60	80%	70%
Syntax	1	Syntax	3	60	70%	60%
Syntax	2	Syntax	3	30	60%	50%
Syntax	2	Syntax	4	60	80%	60%
Syntax	3	Syntax	4	30	60%	50%

Table 2: Prerequisites for L1 domain model

Prerequisite		To		Unlocks next		Locks Next
Linguistic Level	Difficulty	Linguistic Level	Difficulty	Number of Questions	Correct Answers Percentage	Correct Answers Percentage
Phonology	1	Phonology	2	40	50%	40%
Phonology	1	Phonology	3	70	70%	50%
Phonology	2	Phonology	3	40	50%	40%

Phonology	2	Phonology	4	70	70%	50%
Phonology	3	Phonology	4	40	50%	40%
Phonology	1	Morphology	1	50	70%	60%
Phonology	2	Morphology	1	30	50%	40%
Phonology	3	Morphology	2	70	70%	60%
Morphology	1	Morphology	2	40	50%	40%
Phonology	4	Morphology	3	70	70%	60%
Morphology	1	Morphology	3	70	60%	50%
Morphology	2	Morphology	3	40	50%	40%
Morphology	2	Morphology	4	70	70%	50%
Morphology	3	Morphology	4	40	50%	40%
Morphology	1	Syntax	1	50	70%	60%
Morphology	2	Syntax	1	30	50%	40%
Morphology	3	Syntax	2	70	70%	60%
Syntax	1	Syntax	2	40	50%	40%
Morphology	4	Syntax	3	70	70%	60%
Syntax	1	Syntax	3	70	60%	50%
Syntax	2	Syntax	3	40	50%	40%
Syntax	2	Syntax	4	70	70%	50%
Syntax	3	Syntax	4	40	50%	40%

Table 3: Prerequisites for L2 domain model

Tables 4 and 5 list the conditions that must be met for a language level and difficulty pair to move from learning status to practice status, i.e. to be considered as learned or mastered. Similarly, the conditions for the transition from practice mode to mastery mode are recorded. The practice mode refers to features that are to be acquired by the students, i.e. the students understand them at a high level. For L2, Morphology 1 to be considered “mastered” (practice mode), the student must have answered at least 120 questions with a minimum threshold of 70% correct answers. Thus, if the student has answered the 70% correctly, he/she appears to have acquired Morphology 1, but will continue to play with Morphology 1 until he/she reaches the 80%. To be considered “fully mastered” (master mode), the student must have answered at least 140 questions with an 80% success rate. Fully mastered means that the student has fully acquired this level and will no longer play games that contain features from Morphology 1.

Linguistic level	Difficulty level	Number of questions: Practice mode	Correct answers percentage: Practice mode	Number of questions: Master mode	Correct answers percentage: Master mode
Morphology	1	100	80%	120	90%
Morphology	2	100	80%	120	90%
Morphology	3	100	80%	120	90%

Morphology	4	100	80%	120	90%
Phonology	1	100	80%	120	90%
Phonology	2	100	80%	120	90%
Phonology	3	100	80%	120	90%
Phonology	4	100	80%	120	90%
Syntax	1	100	80%	120	90%
Syntax	2	100	80%	120	90%
Syntax	3	100	80%	120	90%
Syntax	4	100	80%	120	90%

Table 4: Cluster mastery thresholds for L1

linguistic level	difficulty level	number of questions practice	correct answers percentage practice	number of questions master	correct answers percentage master
Morphology	1	120	70%	140	80%
Morphology	2	120	70%	140	80%
Morphology	3	120	70%	140	80%
Morphology	4	120	70%	140	80%
Phonology	1	120	70%	140	80%
Phonology	2	120	70%	140	80%
Phonology	3	120	70%	140	80%
Phonology	4	120	70%	140	80%
Syntax	1	120	70%	140	80%
Syntax	2	120	70%	140	80%
Syntax	3	120	70%	140	80%
Syntax	4	120	70%	140	80%

Table 5: Cluster mastery thresholds for L2

3. SPECIFICATION OF GAMES, ACTIVITIES, AND EDUCATIONAL CONTENT

The main objective of this task is to define the learning objectives, tasks and activities to be integrated into the Smart Games component. The educational and playful design of the iRead project was used and adapted to the educational and linguistic needs of bilingual students.

In terms of learning objectives, the D_Read-Narrate project generally aims to improve students' grammatical skills by encouraging them to:

- recognize and use consonant clusters, both at the beginning and in the middle of a word (phonological features).

- practice the specific use of prefixes and suffixes in verbs, adjectives and nouns
- practice the use of nominal and verbal inflectional suffixes
- practice the use of direct and indirect speech, the use of tenses and voice morphology and syntax, the function of main and subordinate clauses, the use and function of personal pronouns.

Specifically, the Smart Games component of the D_Read-Narrate Project involves a series of activities in the form of language games and puzzles which aim to enhance the students' language skills in a fun and motivating way. All games are designed for individual, pair or group activities. These games are considered *smart* as they provide students with individualized support to address their learning difficulties caused either by the complexity of the language, by the fact that Greek is an L2 or by both. In this way, students can improve as the individual support they receive allows them to gradually progress to activities of increasing difficulty and complexity. At the same time, they are guided towards activities that are tailored to their individual characteristics and challenges. The games are designed to promote the skills of automation and accuracy.

The activities, which take the form of games or puzzles, include exercises such as:

- word/sentence formation (e.g. selecting appropriate parts to form a word/sentence)
- accuracy exercises (e.g. placing words in the correct context according to the grammatical category or selecting words that match the instructions given).

Based on the needs of bilingual and monolingual students and the iRead evaluation reports, we selected 5 games from the 15 games that the previous project developed. We selected the following activities from iRead:

Anubrick: In Anubrick, the player is presented with a wall on which a sentence is depicted, with each word appearing on a separate tile in the wall. The player must tap the correct words to answer the question posed in the user interface. In the current version, the player is asked to select the nouns shown in the sentence. Once all the nouns have been selected, the wall retracts into the ground and the player is given another wall to repeat the process. Once the player has solved three questions, they can reach the end of the room and leave the area. (iRead Project (2018). Deliverable 6.3: 5). In a task on temporal sentences, for example, the instruction is: Read the sentence and answer the question: *When did the mother leave?* The following sentence appears on the screen: *The mother left before the end of the performance.* The students must choose: *before the end of the performance.* If the student chooses incorrectly, written feedback will appear: *Think about when the mother left.*

Crocotiles: In Croco-tiles, the player has to solve word puzzles to build a bridge over a body of water and get to the next room. When the player approaches the puzzle, the character automatically moves to the platform to the left of the chasm. The character can then use their magic wand to move pillars around the abyss to solve the word puzzle. Some pillars are already correctly placed on the pedestal and the player must

move the correct pillars from the remaining selection to solve the puzzle correctly. (iRead Project (2018). Deliverable 6.3). For example, in a task about suffixes, the instruction is: *Choose the correct suffix to form the word **anthropos** (man).* The following selection appears on the screen: *anthrop_: os- i, is.* Students must choose: *os.* If the student chooses the wrong suffix, written feedback will appear: *Read the word again and check that it is correct.*

Perilous paths: To play Perilous Paths, students should approach the rope. The game will begin, and the player is presented with a sentence which contains a blank space. Tap the rope bridge that shows the correct word to fill the blank in the sentence. When the correct bridge is selected, the sentence will be read aloud and the player will be able to progress to the next set of rope bridges and the next sentence. Once the player has solved five sentences, they will reach the end of the room and can exit the area. (iRead Project (2018). Deliverable 6.3: 5). In a task on complex prepositions, for example, the instruction is: *Form a correct sentence by choosing the right word.* The following sentence appears on the screen: *The singer stumbled ___ the end of the concert.* Students must choose: *pano apo (over)* instead of the distractor *prin apo (before)*. If the student chooses incorrectly, written feedback will appear: *Choose the word that best completes the sentence.*

Watch your step!: The children are presented with the task of identifying the correct word out of 3-5 words presented to them. The game asks the player to take around five steps across a chasm, only the correct choice will enable the avatar to move across. Thus, the pupil sees around 25 words in each game and makes around 5 choices. The game lasts around 1-2 minutes. (iRead Project (2021). Deliverable 9.3). For example, in a task on consonant clusters, the instruction is: *Choose words that begin with **sp**.* The following choices appear on the screen: *spiti (house), spourgiti (sparrow), stavraetos (crossbill), skouliki (worm).* The pupils have to choose: *spiti, spourgiti.* If the student chooses incorrectly, written feedback appears: *Try again.*

Bridgypatian: Entering the room and climbing the stairs will begin the puzzle. The player must drag and drop pillars that contain the correct stem word from the back wall onto the puzzle holder position. Upon doing so the pillars will disappear into the floor replaced by the next question. Upon 3 correct answers the bridge opens and the player can walk to the next puzzle. (iRead Project (2018). Deliverable 6.3: 3). This game is like crocotiles. For example, in a task on complex consonants, the instruction is: *Choose the correct letters to form the word **laspi** (mud).* The following selection appears on the screen: *la_i: s, p, t, k.* The student must choose: *s and p.* If the student chooses incorrectly, written feedback appears: *read the word again and check that it is correct.*

The D_Read-Narrate Games have the same function, but different names and properties (see D9 attached). The D_Read-Narrate software contains additional supporting applications designed to improve the teaching and learning process for both teachers and students. These applications offer various tools and functions that facilitate effective teaching.

Additional to the Smart Games, D_Read-Narrate includes an essential component, a set of **Teacher Tools**, which allow teachers to access a personalized account that provides tailored resources to support their teaching. Through their profile, teachers can complete scorecards to assess and provide feedback on students' oral storytelling, create digital classrooms for collaborative tasks such as game tournaments,

group storytelling, monitor students' performance in language and reading activities, track their progress and assign them appropriate tasks. In addition, students have **personal profiles** where they can save their achievements, save the stories they create, view their scores, and update the Smart Games with their achievements and content choices to ensure a personalized learning experience. This is achieved through the **User Model**, which continuously tracks the learner's performance and dynamically adjusts both the difficulty level and the selection of games and language material. By adapting to the needs of each learner, the system provides targeted support, promoting the effective development of reading skills.

Since the learning needs of bilingual Greek speaking children are also addressed in the current project, the software includes a Language Level Assessment (Screening) Tool (https://D_Read-Narrate-narrate.gr/narrate-screening/), which allows educators to quickly assess students' language skills before their first interaction with D_Read-Narrate software, as well as throughout the learning process. Specifically, the validated tests "Let's Speak Greek" (II, III), which were developed to assess the level of language proficiency of bilingual Greek speaking students (Tzeveleku et al. 2004), were adapted for use on tablets, with the permission of the research group that designed them. We technically adapted and used the sections on auditory comprehension, written comprehension and grammar, excluding language production. The "Let's Speak Greek II" test is suitable for children aged 8 to 11 years at A1 to B1 proficiency levels, while the "Let's Speak Greek III" test is suitable for children aged 10 to 12 years at A2 to B2 levels. The rubric was adjusted accordingly to score up to 45 points. This tool can also be used during and after engagement with the Smart Games and reading/ narration activities to track progress and performance, as well as the impact of the software on student language development.

To conclude, during last year, the following tasks were completed, as these were described in the research proposal for WP2. In adapting the domain models, we regrouped the remaining language features based on linguistic level and difficulty improving the progression of activities in iRead, which were previously slow to progress. The updated framework now includes four difficulty levels instead of seven, allowing for larger groups and faster progression. The difficulty levels were designed differently for monolingual and bilingual students. We have adapted and linked smart games to the adapted domain models. This involves selecting and adapting five games from the original set to practice the language feature groups. We also set the success rates required for students to progress to different difficulty levels, using different thresholds for monolingual and bilingual learners. Finally, we have adapted the "Let's Speak Greek" tests for use on the tablet to determine the language level of the students.

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5. APPENDIX

APPENDIX 1. List of the new added features

Adverbial Clauses: Cause	jiati (because)	O adras htipise to ayori jiati filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC because kissed_3SG.PAST.PERF the_ACC woman_ACC. =The man hit the boy because he kissed the woman.
Adverbial Clauses: Cause	epeidi (because)	O adras htipise to ayori epeidi filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC because kissed_3SG.PAST.PERF the_ACC woman_ACC. =The man hit the boy because he kissed the woman.
Adverbial Clauses: Purpose	ja na (to)	O adras etrekse gia na filisei ti jineka. The_NOM man_NOM ran_3ST.PAST to kiss_3SG.PR.PERF the_ACC woman_ACC. =The man ran to kiss the woman
Adverbial Clauses: Cause	afou (because)	Afou arjise na paei de vrike psomi ston fourno. Because was late_3ST.PAST he_NOM didn't find_3ST.PAST.NEG bread_ACC in_PREP the_ACC bakery_ACC. =Since he was late to go, he couldn't find bread in the bakery.
Adverbial Clauses: Contrast	eno (though)	O adras htipise to ayori eno filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC though he_NOM kissed_3SG.PAST.PERF the_ACC woman_ACC. =The man hit the boy though he kissed the woman.
Adverbial Clauses: Contrast	an kai (though)	O adras htipise to ayori an kai filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC though he_NOM kissed_3SG.PAST.PERF the_ACC woman_ACC. =The man hit the boy though he kissed the woman.
Verb aspect: Perfective	Prin (before)[+p erf.], otan (when)[+pe rf.], afou (after)[+per f.], an (if)[+ perf.]	O adras htipise to ayori prin filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC before kiss_3SG.NONPAST.PERF the_ACC woman_ACC. =The man hit the boy before kissing the woman.
Verb aspect: Perfective vs. Imperfective	Otan [+perf.]/ otan[- perf.], afou [+perf.]/afo u[-perf.], an[+perf.]/a n[-perf.]	O adras htipise to ayori otan filise ti jineka. The_NOM man_NOM hit_3ST.PAST the_ACC boy_ACC when kissed_3SG.PAST.PERF the_ACC woman_ACC. =The man hit the boy when he kissed the woman.
Complement clauses: Indirect Qs	Pou (where)/ pos (how) / pote (when)/jiati (why)/poio s (who)/ti (what)	O adras apori jiati o athlitis filise ti jineka. The_NOM man_NOM wonders why the_NOM athlete_NOM kissed_3SG.PAST.PERF the_ACC woman_ACC. = The man wonders why the athlete kissed the woman.

Relative Clauses: ton opjo	<i>O/O Relatives - Anaphoric complemen t Right Branching</i>	O adras ide to giatro ton opio htipise o aθlitis xθes. The_ _{NOM} man_ _{NOM} saw_ _{3SING.PAST} the doctor_ _{ACC} who hit the_ _{ACC} athlete_ _{ACC} yesterday. =The man saw the doctor who hit the athlete yesterday.
Relative Clauses: ton opjo	<i>S/O Relatives – Anaphoric complemen t Center Embedding</i>	O adras ton opjo htipise o aθlitis ine ilikiomenos. The_ _{NOM} man_ _{NOM} who hit the_ _{ACC} athlete_ _{ACC} is old. =The man who hit the athlete is old.