EDUCATIONAL MATERIAL ORGANIZATION IN A PLATFORM FOR GREEK SIGN LANGUAGE SELF MONITORING AND ASSESSMENT

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Abstract

SL-ReDu is a project that focuses on learning and assessing Greek Sign Language (GSL) as a second language, integrating state-of-the-art sign language (SL) recognition technology. It supports self-monitoring of productive learning and objective evaluation, addressing: a) teaching large student populations at a tertiary level; b) assessing SL skills in an objective way; and c) interacting digitally, without the presence of a human evaluator. Achieving such goals requires an interdisciplinary effort, employing state-of-the-art techniques in language didactics, sign linguistics, and handling of large amounts of SL data, while exploiting innovative methods in human-computer interaction, computer vision and machine learning [1]. The SL-ReDu educational material provides content to an innovative educational platform for enhancing and testing GSL competence of non-native (L2) users. It provides adequate linguistic input that consolidates new knowledge on all grammar levels of the target language. A total of 14 semantic units combined with major grammar features of GSL are catered for by the interface design, providing pedagogically and morphologically structured language learning activities, both passive and active. Traditional SL learning and assessment require tutor individual involvement for each student or small group in order to guarantee visual attention and correction of articulation, which occurs in 3D space around the signer, with numerous upper-body active articulators through movement of the hands, head, shoulders and torso, mouth gestures, eye and eyebrow movements and gaze, all carrying grammatical information [2]. These parameters have all been taken into account in a signer-independent fashion, accounting for natural variability among signers. Within the self-monitoring environment of the SL-ReDu platform, students practicing with productive language skills can record their responses on their personal computer, upload them to the platform, where they are processed by an automatic recognition engine, and receive feedback on their performance as many times as necessary until they achieve a given learning goal. On the contrary, while taking an exam, students are allowed to provide their answers only once, both in active and passive test tasks. In this way, the environment of GSL activities and assessment ensures credibility and consistency of test results efficiently and cost-effectively. The SL-ReDu project, designed to support a large student population attending GSL courses (CEFR-L levels A0-A1) at Tertiary Education in Greece, includes two phases of evaluation and validation by end-users, the first of which is planned to take place in September 2021.

Keywords: sign language learning, second language learning, self-assessment, online testing, sign language recognition.

1 INTRODUCTION

The quest for inclusion and accessibility of the Deaf and Hard-of-Hearing (HoH) has driven major advances in sign language (SL) study, teaching methodologies and technologies in the areas of linguistics, education, computer engineering, and human-computer interaction, among others. While a significant amount of literature has been published on the progress in these areas impacting the Deaf and HoH (1‰ of the general population) [3], [4], there is still some way to go in research and applications on SL learning and testing as a second language (L2) for the hearing population involved with the Deaf and HoH, i.e. those involved in deaf and special education, training and care, and communication support in all aspects of human-human interaction (i.e. legal affairs, healthcare, employment, governmental issues, etc.) [5]. Family members of hearing impaired people, as well as postlingually deafened people and users of cochlear implants, who have not had the opportunity of learning a SL in spontaneous settings also belong to the group of SL users as L2 [6], [7], [8]. Their number is cumulatively estimated to 1% of the general population [7], [9], with numbers rapidly increasing.

Most Greek Sign Language (GSL) schools in Greece still largely follow language immersion and experiential approaches, as there is no uniformly followed methodology of teaching and assessment despite recent developments on GSL education. In social distancing free periods, an average group size of GSL students typically consists of 4 to 8 persons, while, upon application of social distancing measures, group sizes drastically fall to one to three students per tutor in online learning environments. Besides the obvious impracticalities that arise, the need for research and innovations in methodology and infrastructure of GSL teaching is more urgent than ever for students and tutors to work, exercise, or be assessed online. Tutor dependency is an additional major factor compromising objectivity, uniformity, and learning outcomes for asynchronous teaching and testing [10]. The Pedagogical Department of Special Education at the University of Thessaly (UTH) has implemented GSL teaching in four undergraduate modules and in 2018 was the first Greek institution to adopt the guidelines set by the Common European Framework References for Languages (CEFR-L), amended for SLs in 2015 for L2 levels A0 to A2 and in 2020 for L2 levels B and C [11]. However, briefly after the application of the CEFR guidelines and especially upon social distancing restrictions since 2020, the need for re-organisation of the educational GSL material became prominent. With student numbers of no less than 150 per semester, teaching GSL in small groups at university would not only be cost- and time-ineffective but would not guarantee objectivity and uniformity of results. Online learning needs to address additional issues of connectivity and network speed, while monitoring the GSL production skills of each individual student in groups of this size, is severely limited.

The present study describes how the educational material developed in the SL-ReDu project addresses these upcoming issues in GSL learning and testing as a second language online. Where necessary, some information on the technological and technical aspects that are unique to SL transmission is provided for a better understanding of the situation. SL-ReDu deals with GSL as L2 at a beginner's level (A0-A1), applying appropriate teaching methods and implementing state-of-the-art technological features on a specially designed platform of online learning. The educational material, albeit linguistic in nature, calls for adaptations for an optimal use of the visual-motor modality and culture of SLs, using no audio prompts or feedback and minimal written prompts in L1. The methodology, technology, and technicalities deployed for the organisation of the material have been specifically designed towards full functionality in a SL environment, addressing the scarcity and inadequacies of existing GSL educational applications. Throughout the material, basic GSL theory, lexicon, and grammar phenomena are introduced, as well as drilling on manual and non-manual articulation, covering the curriculum of one semester (approximately thirteen weeks of study). The educational material provides a set of self-monitoring exercises as well as tutor independent assessment tests in the areas of perception and production in L2.

2   METHODOLOGY

The language material organization takes into account the idiosyncrasy of signed languages, which use the 3D space to convey linguistic meaning, and hereby adopts a critical stance towards current trends which are usually based on assumptions on Indo-European spoken language learning, but not always suitable for SLs [12]. The time-span and learning units allowed for a course that takes place over a university semester which are attended by true beginners also inform the design and layout of the material. Grammatical and articulatory (phonetic and phonemic) issues that the material foremostly caters for help beginner students to get a clear idea of the fundamental properties of SLs versus oral languages. Indeed, there is little in common between Greek, spoken or written, and GSL, both in structural and in functional level, although both are used in the same geographical area. Oral languages use the auditory-oral channel and SLs use the visual-motor channel of transmission [13], [14]. It is essential for the expressive skills of the SL students to successfully activate articulatory systems that include both manual (i.e. handshape, motion pattern, hand relative position, and orientation) and non-manual (i.e. body posture, facial expressions, and body motion) articulators even for the formation of basic SL signs [15]. In the area of both SL articulation and perception, it is necessary for the students to have acquired 3D linguistic structures that are unfamiliar to them [16], [17], as their majority are native users of Indo-European spoken languages.

Besides grammar issues that had to be taken into account, the platform functions had to deal with technological issues specific to the visual properties of GSL avoiding interlinguistic involvement, i.e. with no use of the spoken language and highly functional use of video. The focus here remains on ease of navigation and optimal achievement of the learning target. Through the application of the UTH GSL curriculum on the SL-ReDu platform, the material accurately presents the 3D nature of SLs as well as their morphosyntactic structures [18] and provides the learner with plenty of practice

opportunities on new knowledge and skills [19], [20], [21], [22]. Large amounts of linguistic data, either performed by native GSL signers or a signing avatar, have been exploited for the content presentation in the platform. SL production by the students is possible through the material implementation and design, using state-of-the-art technology of automatic recognition of SL manual and non-manual features.

Tutor-independence and allowing for unlimited time of self-study for each student involved, without the need for specialized equipment, are additional prerequisites that make the SL-ReDu material unique in its kind. In this manner, each individual participant can study in their own space and time for optimal development of the visual-perceptual and motor-productive skills related to SL learning, a goal that has not been reached previously in the case of GSL [23].

Each grammatical unit is preceded by a presentation of the content included for L2 level A, as is described in detail in the organisation of the content in the material. The self-monitoring and testing units of listening and reading, as well as writing and speaking in a foreign language, are respectively replaced by their visual counterparts of viewing and perceiving signing. The language material of SL-ReDu has incorporated spelling bees, multiple choice tasks (see Figure 1, for example), having a short virtual conversation, answering a quiz, and solving a simple math problem, following current trends in language learning exercises [24], including widespread types of exercises for language learning such as repetition, permutation exercises, matching exercises with fingerspelling letters and words against video or picture equivalents, matching object pictures against signs, as well as multi-choice and category exercises for lexicon and grammar phenomena. For each self-monitoring or self-assessment activity, upon submission of a satisfactory performance, the learner can proceed to the following exercise and earns a token. An unsatisfactory performance either: a) prompts the student to repeat the exercise, or b) subtracts a token from the evaluation total.

Figure 1. Example of a multi-choice exercise (concerning classifiers for human entity).

Grading of each exercise can take various values that sum up determining the pass/fail threshold of a learning unit. At this stage, these are currently pre-set in the platform. Flexibility of timing for each unit and/or activity helps improve student skills by initially allowing the student to opt for a non-timed exercise, or choose the option for more time allowed at a test, or even take a simulation test and record the time required to complete the activity, before taking the actual test, which is a prerequisite for passing or failing part of the official university module.

Overall, the layout of the GSL educational material aims at maximum time effectiveness, irrespectively of the number of students who take the course and of the breadth of learning units undertaken at any given time of the semester in a measurable and objective way. For exercising or testing in SL as L2, it is necessary to incorporate features of SL recognition in the sets of self-monitoring as well as assessment [25], [26], [27]. Validity of spoken or written language production evaluation has progressed over the last decades, by means of voice and text recognition technologies. In the area of SLs, however, the lack of assessment tools is apparent, even more so when human interaction needs to be excluded from the process. In addition, learning a signed language from a visual-motor modality differs from learning a second spoken language significantly [7], [28], [29], thus complicating assessment. Various degrees of accuracy and acceptability of the student responses can be taken into consideration and not dismissed overall, through use of the SL-ReDu educational material.

Evaluation phases and feedback from end-users are an internal part of the methodology after completing the platform development stages. A two-phase usability testing includes responses from subjective evaluation questionnaires by volunteer evaluators as well as objective results of their

submitted answers, all of which will provide information on the objectivity, validity, usability, and functionality of the platform, along with overall experience, user trust, and ease of navigating, as well as other possible factors, such as design templates or the time assigned for each activity.

3   EDUCATIONAL CONTENT ORGANISATION

3.1   Lexicon

Manual sign productions, i.e. parts of the language conveyed by the hands of a signer, as well as non-manual productions, i.e. productions realized through movement of other parts of the body, such as the eyes, cheeks, torso, and shoulders, are incorporated in the educational material. The sets of manual sign productions comprise of: a) single-sign manual productions, b) short phrases in the form of sequences of signs, and c) sets of phrases with non-sequential contrastive morphosyntactic features. Single-sign manual productions in the educational material comprise of approximately 500 isolated signs (398 unique isolated lexical signs, plus one hundred of fingerspelled sequences). The semantic and structural organization criteria of the language material on the level of single signs is based on the semantic categories included in the curriculum of the introductory course in GSL, as well as on the morphological and articulatory features according to handshape, type of movement, single- or double-handedness, and symmetry of movements between the two hands.

3.1.1   Semantic Categories in the Lexicon

The introductory course in GSL has a duration of thirteen weeks, and at a lexical level it must cover monomorphemic isolated signs of the semantic categories, followed by the numbers of corresponding signs per category (see Table 1, below). These categories are in line with SL teaching at beginners' level, including some additional isolated grammar signs, classifiers, and fingerspelling characters, among others, and adding the generative value of the content vocabulary.

Table 1. Distribution of isolated signs (lexemes) in semantic categories.

Thematic category	# lexemes	Thematic category	# lexemes
Getting to know each other	40	Home	25
Everyday items	17	Clothes	17
Family	19	Work	16
Drinks and snacks	42	School	8
Landscape	35	Colours	6
Shopping	9	Transport	10
Numbers	38	Time concepts	13

Use of the lexical signs belonging to the above categories distributes evenly throughout the thirteen or fourteen weeks of the course semester, covering all of the expected vocabulary, while some words may also apply to following courses. These lexical signs also form the pool for phrase and sentence formation in the units of morphological and syntactic phenomena. Units of classroom communication also draw from these semantic units, complying with the CEFR-L criteria for A0-A1 levels.

3.1.2   Numerals

Numerals, albeit lexical in semantics, form a special case in the GSL lexicon, as to their generative dynamic when included in the language material of SL-ReDu. All numbers from 0 to 999,999 have been included, using a basis of 38 recorded signs that can be multiplied by the corresponding combinations of numerals, extending the possible articulations of numbers by the highest number included in the set. There has been provision for recognizing and producing both interpersonal and geographic variations of GSL. While students at the introductory level are not required to use numbers beyond one hundred, it is considered essential that the language material includes all numbers, expanding its usability. Moreover, numbers are morphologically incorporated into time concepts in

GSL in phrases like, e.g. *three days ago,* as well as with quantifier phrases using shape classifiers, such as, for example, in the phrase *two apples*.

3.1.3 Structural Categories of the Lexicon

Beginner L2 students are usually introduced to phonologically and morphologically simple items in all levels of the grammar, avoiding words and phrases that require finer perceptual and articulatory skills. In this respect, isolated signs, as well as drills and exercises mostly contain items with the following features: a) over the elbow articulation, b) single-handed articulation, b) double-handed symmetrical articulation, and d) possible internal change of handshape through movement. GSL handshapes, in particular, are in the most part limited to the thirteen most common forms and their variations. These handshapes account for the majority of the linguistic productions in GSL and are prioritized due to their articulatory straightforwardness and to their high frequency of use at this level [30]. Handshape classification follows the HamNoSys notation system, as one of the most widely established SL annotation systems internationally [31]. It should be noted, however, that from a didactics perspective the need for full coverage of specific semantic areas in the introductory course, isolated signs using eight less frequent handshapes have also been included in passive drills to accommodate for the anticipatory difficulty in handshape recognition. The thirteen most frequent handshapes that most of the isolated signs are formed with, are illustrated in Figure 2, below. The less frequent handshapes that were included for didactic reasons are not illustrated, as their occurrence is sparse and unsystematic for a structural analysis.
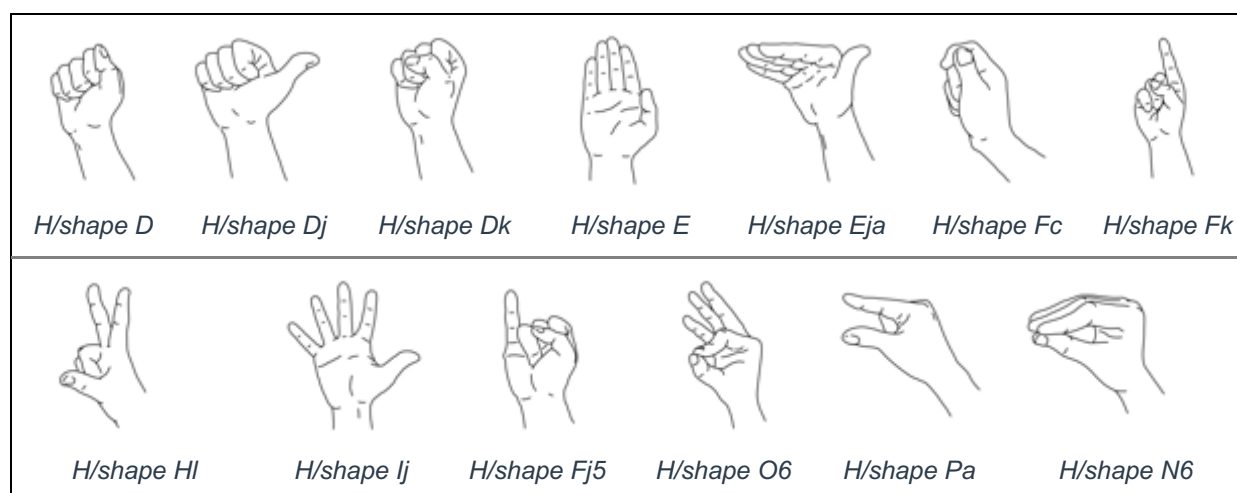

| H/shape D | H/shape Dj | H/shape Dk | H/shape E | H/shape Eja | H/shape Fc | H/shape Fk |

| H/shape Hl | H/shape Ij | H/shape Fj5 | H/shape O6 | H/shape Pa | H/shape N6 |

Figure 2. Main thirteen handshape configurations of the isolated sign content.

3.1.4 Fingerspelling

The set of manual representations for the letters of the Greek alphabet do belong to the manual isolated sign set, but do not in any case form a lexical, or for any matter, a linguistic category in SLs. Fingerspelling is a transcription system to represent the characters of an alphabet via conventionalized hand gestures, resulting in a total of 24 Greek fingerspelling symbols, with the addition of a special word-dividing manual sign for the expansion of the dynamics of fingerspelling for producing not only single-word depictions but a virtually infinite string of Greek words or sentences through the use of the educational material, either in production or in perception exercises and tests.

The set of fingerspelled single- or two-word clusters consists of words with no lexical equivalent in GSL, as this is the case in real-life use, when using fingerspelling. Semantic criteria on the word selection from the four most common language areas where fingerspelling is used, i.e. place names, random people names, student's own full name, brand names, as well as terms in arts and sciences.
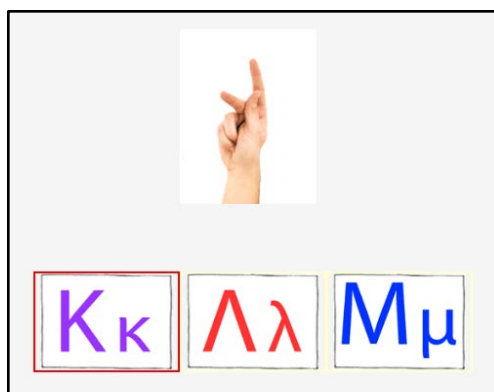
Figure 3. Example of a fingerspelling multi-choice exercise.

3.2 Morphology and Morphosyntax

Syntax and morphology of SLs, as well as spoken languages are often intertwined as morphophonology and morphosyntax. In this respect, bound grammatical morphemes are also part of the syntactic level, when marking for syntactic relations at the sentence level. At the syntactic level, the language material is divided in two different subsets: a) sets of phrases to demonstrate grammar phenomena and b) short phrases essential for communication at L2 levels A0-A1. At the morphological level, two types of morphology inflections are dealt with in the educational material:

a) Manual grammatical markers in the form of isolated signs of grammatical meaning and function. These manual grammatical morphemes include indices, which work as pronouns / determiners, possessives, completive markers, question and negation markers.

b) Bound grammatical markers in the form of morphemes articulated as a modification of one or more internal parameters of the manual lexical sign. Bound grammatical inflections for yes/no and wh-questions, person agreement, negation, number and quantities are included in the material.

At a syntactic level short phrases either as part of the learning of the grammar or as part of learning drills and exercises have been created, using the core 500 isolated signs vocabulary described in the Methodology Section. The structures in the grammar areas included in the language material draw heavily from the findings documented in the SignGram Blueprint [32]. A total of 762 different phrases have been created applying GSL grammatical rules in the Noun Phrase and the Verb Phrase, while these can generate multiple times this number.

3.2.1 Noun Phrase

At the Noun Phrase (NP) level, the educational material deals with simple combinations of nouns and their complements, albeit following different order from spoken Greek and incorporating use of 3D signing space as well as non-manual articulation. Main categories dealt with in the NP are illustrated in Table 2, below, and provide examples on:

– numerals (plain numerical phrases, temporal inflection of numerals, money, and numbers);

– noun-and-adjective, as well as noun-and-quantifier phrases;

– plain coordination using *and / or*, possession;

– pronominals combined with nominals.

Possession in the NP is also presented in human – non-human relations of alienable possession in the affirmative, interrogative, and negative forms (two morphological variations) in all persons [32]. Pronominal reference is limited to the examination of Person marking using Indices [33], which work at language learning level A for unmarked sentences.

Table 2. Examples of spatial inflections in the NP included in the material.

Category	Greek glossing	English glossing	English translation
Plain numerical NP	ΜΗΛΟ ΔΥΟ2hCl-3D	APPLE TWO 2hCl-3D	Two apples
Temporal numerals	ΜΕΡΑ^ΤΕΣΣΕΡΑ	DAY^FOUR	Four days
Possessive inflection	Poss-loc3	Poss-loc3	his/her
Possessive inflection	Poss-loc2a-2b-2c	Poss-loc2a-2b-2c	your (plural)

3.2.2 Verb Phrase

Some of the most common grammar phenomena on the Verb Phrase (VP) are presented (see Table 3, below) in order help the student understand the mechanisms of GSL for:

a) Subject, Verb and Object sequences in all three inflectional verb categories in GSL [34], i.e.: Plain Verbs, Agreement Verbs, Locative and Movement Verbs.

b) Interrogative sentences, some of which not yet documented upon, with temporal information incorporated in the wh-question particles for 'when', denoting distant or immediate Past or Future.

c) Negation in GSL in the morphosyntactic as well as in the lexical level, with different negation markers is included in short phrases combined with systematic non-manual marking [35].

d) Quantifiers, which rely heavily on the 3D properties of objects in SLs [36] and on mouth gestures, multiply the types of quantifiers in both the NP and the VP.

e) Aspectual marking for Perfect is included in the sets of affirmative, interrogative and negative forms of short sentences, as it is obligatory in GSL, systematically marking the verb for aspect but not for tense, in contrast to spoken Greek language [37].

f) Some instances of subordination of sentences using the verb CAN, WANT and LIKE for reasons of communication of likes, dislikes, and abilities.

Table 3. Examples of morphosyntactic inflections in the VP included in the material.

Category	Greek glossing	English glossing	English translation
Plain Verbs	Ix-loc3 ΓΑΛΑ ΑΡΕΣΕΙ	Ix-loc3 MILK LIKE	He/she likes milk
Agreement Verbs	$_3$ΑΠΑΝΤΩ$_2$	$_3$REPLY$_2$	He/she replies to you
Locative Verbs	ΜΠΑΛΑ 2hCl-3D loc1-5	BALL 2hCl-3D loc1-5	I throw the ball
Interrogation	Ix-loc2 ΑΜΑΞΙ ΑΓΟΡΑΖΩ _____WHq ΠΟΤΕnear-past WHq	Ix-loc2 CAR BUY _____WHq WHENnear-past WHq	When did you buy a car (recently)?)
Quantifiers	ΝΕΡΟ ΛΙΓΟ(vertical axis)	WATER LITTLE(vert.)	A little water
Aspectual marking	Ix-loc1 ΜΕΛΕΤΩ [+compl]	Ix-loc1 STUDY [+compl]	I have finished studying
Subordination	Ix-loc2 ΟΔΗΓΩ ΔΕ-ΜΠΟΡΩ	Ix-loc2 DRIVE CANNOT	you cannot drive

3.2.3 Classifiers

Classifiers in SLs carry semantic values assigned to single objects or to classes of objects. They also function as enclitic pronominals expressed in the 3D space [36]. The SL-ReDu language material, corresponding to levels A0 and A1, focuses mainly on single-handed classifiers with plain or no movement, or classifiers articulated with symmetrical handshape movement in both hands. Simultaneous production of two-handed plain classifiers are included in the language material for relative positions marking (e.g. the apple falls from a tree). From a semantic point of view, classifiers for human, vehicle, single-point (no dimension) objects, one-, two-, and three-dimensional objects,

size-and-shape outline, small-entity, are part of the learning curriculum included in the educational material, as is illustrated in Figure 4.

Figure 4. Example of a matching exercise on human entity classifiers.

3.3   Classroom Communication

A set of 32 short phrases that do not belong to any of the groups described above but are essential for classroom communication is also part of the Introductory course curriculum and covers the communication areas required for A0-A1 level students. These include short statements and questions on name, age, occupation, accommodation, preferences, class involvement, as well as short statements and phrases on expression of judgement, objects, common routines, and events, such as in Table 4, below.

Table 4. Examples of common phrases for communication in the material.

Category	Greek glossing	English glossing	English translation
Preferences	ΚΑΦΕΣ Ix-loc3 ΑΡΕΣΩ Ix-loc3	COFFEE Ix-loc3 LIKE Ix-loc3	He/she likes coffee.
Personal info	____Y/Nq Ix2 ΑΔΕΛΦΙΑ ΕΧΩ Ix2	____Y/Nq Ix2 SIBLINGS HAVE Ix2	Do you have siblings?

4   CONCLUSIONS

The educational material of SL-ReDu fully meets the educational prerequisites for A0-A1 levels of CEFR-L, covers all levels of grammar (phonology, morphology, syntax), and expands in lexical categories expected for communication at this learning stage. The content in core grammar and lexicon enable the learner to experience the natural productivity of the language by comprehending the unlimited potentials for building of new utterances. This material allows for full development of the learner's skills in passive language tasks like comprehending signed language messages as well as productive language skills where the learner is required to produce his/her own linguistic message.

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