D6.4 Publicity and Dissemination Report for Y3

SL-ReDu
Sign Language Recognition in Education

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Executive Summary

The SL-ReDu project aims to advance the state-of-the-art in the automatic recognition of Greek Sign Language (GSL) from videos, while focusing on the education use-case of standardized teaching of GSL as a second language. In this deliverable (D6.4), we present the dissemination activities during the third (final) year of the project (M27-M42), which primarily included publications and presentations at international conferences, as well an open-access journal publication. It is worth noting that the SL-ReDu project has yielded 16 publications during its life-span of 3.5 years (42 months).

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1 Introduction

Dissemination represents an important activity of research projects, as it allows spreading of the developed knowledge in a timely fashion to the scientific, stakeholder, and general public communities, while also allowing funding agencies to gauge project impact and investment return, as well as resulting to visibility of all parties involved. For this purpose, the SL-ReDu project has assigned a dedicated task (T6.1) of workpackage WP6 in its Technical Annex to the project dissemination activities, which remains active over the entire project duration with its activities reported yearly.

In this deliverable (D6.4), we overview the SL-ReDu dissemination activities during its third year (M27-M42), following corresponding deliverables D6.1 [1] and D6.2 [2] that covered its first year (M01-M12) and second year (M13-M26), respectively. Since the project logo, website, brochure, and poster were developed in Y1 and thus reported in D6.1, here we primarily cover scientific dissemination by means of papers and their presentations during Y3.

More specifically, we discuss:

- The publications of research work related to SL-ReDu (Section 2).
- The presentations of the project at various fora (Section 3).
- Any other dissemination activities, including student education activities (Section 4).

Finally, in Section 5 we outline some of our planned future dissemination activities, and in Section 6 we conclude the deliverable.

2 The SL-ReDu Publications During Y3

Following five scientific publications during Y1 of the project and an additional three during Y2, in Y3 an additional eight have appeared or been accepted for publication in well-established peer-reviewed international conferences and a journal. Thus, a total of 16 publications have been made during the life-span of the SL-ReDu project (all of which are available on the SL-ReDu website (URL: https://sl-redu.e-ce.uth.gr/publications)), constituting the primary means of scientific dissemination of the project work.

More specifically, the Y3 papers are listed next:

- K. Papadimitriou, G. Potamianos, G. Sapountzaki, T. Goulas, E. Efthimiou, S.-E. Fotinea, and P. Maragos, "Greek sign language recognition for an education platform," *Universal Access in the Information Society* [Open Access], 2023 (DOI: 10.1007/s10209-023-01017-7).
- K. Papadimitriou and G. Potamianos, "Multimodal locally enhanced transformer for continuous sign language recognition," in *Proceedings of the Conference of the International Speech Communication Association (INTERSPEECH)*, pp. 1513–1517, 2023 (DOI: 10.21437/Interspeech.2023-2198).
- G. Sapountzaki, E. Efthimiou, S.-E. Fotinea, K. Papadimitriou, and G. Potamianos, "Remote learning and assessment of Greek Sign Language in the undergraduate curriculum in COVID time," in *Proceedings of the International Conference on Education and New Learning Technologies (EDULEARN)*, pp. 5452–5459, 2023 (DOI: 10.21125/edulearn.2023.1431).
- K. Papadimitriou, G. Sapountzaki, K. Vasilaki, E. Efthimiou, S.-E. Fotinea, and G. Potamianos, "SL-ReDu GSL: A large Greek Sign Language recognition corpus," in *Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing Workshops (ICASSPW) – SLTAT 2023: Eighth International Workshop on Sign Language Translation and Avatar Technology*, pp. 1–5, 2023 (DOI: 10.1109/ICASSPW59220.2023.10193306).
- K. Papadimitriou and G. Potamianos, "Sign language recognition via deformable 3D convolutions and modulated graph convolutional networks," in *Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, pp. 1–5, 2023 (DOI: 10.1109/ICASSP49357.2023.10096714).
- G. Sapountzaki, E. Efthimiou, S. E. Fotinea, K. Papadimitriou, and G. Potamianos, "3D Greek Sign Language classifiers as a learning object in the SL-ReDu online education platform," in *Proceedings of the International Conference on Education and New Learning Technologies (EDULEARN)*, pp. 6146–6153, 2022 (DOI: 10.21125/edulearn.2022.1449).
- K. Papadimitriou, G. Potamianos, G. Sapountzaki, T. Goulas, E. Efthimiou, S.-E. Fotinea, and P. Maragos, "Greek Sign Language recognition for the SL-ReDu learning platform," in *Proceedings of the 7th International Workshop on Sign Language Translation and Avatar Technology: The Junction of the Visual and the Textual: Challenges and Perspectives* (Satellite Workshop to the *Language Resources and Evaluation Conference (LREC))*, pp. 79–84, 2022 (URL: https://aclanthology.org/2022.sltat-1.12).
- M. Parelli, K. Papadimitriou, G. Potamianos, G. Pavlakos, and P. Maragos, "Spatio-temporal graph convolutional networks for continuous sign language recognition," in *Proceedings of the IEEE International Conference on Acoustics, Speech and Signal Processing (ICASSP)*, pp. 8457–8461, 2022 (DOI: 10.1109/ICASSP43922.2022.9746971).

Note that the last publication in this list has already been accepted during Y2 of the project, thus also listed in D6.2 [2] (but appeared in Y3), whereas the first two have been accepted towards the end of the project's Y3 (and appeared shortly thereafter). The first page and the acknowledgment page of the first publication listed above (open-access journal) is shown in Figure 1.

Universal Access in the Information Society
https://doi.org/10.1007/s10209-023-01017-7

LONG PAPER

Greek sign language recognition for an education platform

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Abstract
Recent advances in sign language (SL) technologies, along with demand for SL education, have led to increased interest in developing tools that enable automatic assessment of learners' SL video productions, helping both students and their instructors. At the very least, such tools should perform automatic SL recognition (SLR) of non-studio quality videos in a signer-independent (SI) fashion, thus providing simple binary feedback on learners' signing under realistic usage scenarios. Motivated by the above and the lack of any such tools for the Greek SL (GSL), we have been developing the "SL-ReDu" education platform for both receptive and productive GSL learning and student assessment. In this paper, we present our SLR module for GSL, developed for and integrated to the "SL-ReDu" system. The module incorporates state-of-the-art deep-learning based visual detection, feature extraction, and classification, operates in an SI mode on web-cam videos, and accommodates a small-size vocabulary of isolated signs and continuously fingerspelled letter sequences. We train the module on collected GSL data and demonstrate its superiority over a number of alternative SLR algorithms. We then conduct its objective evaluation within the "SL-ReDu" system and carry out a subjective evaluation of the overall platform, obtaining very satisfactory results in both.

Keywords Sign language recognition · Greek sign language · Education tools · Sign language assessment · MediaPipe · MobileNet · ResNet · BiLSTM

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1 Introduction

Sign languages (SLs) comprise a complex non-vocal form of communication, which occurs in the 3D visible space around the signer's upper torso, encapsulating both manual and non-manual articulation, each carrying gloss linguistic content [1]. Due to its intricacy, learning an SL as a second language (L2) constitutes a challenging and time-consuming process for both students and their instructors [2]. Importantly, students need regular feedback on their SL productions during learning, which may not be available at all times by their instructors (e.g., at home and at a leisurely learning pace). Further, the currently used assessment procedures yield significant instructor workload, as they rely exclusively on manual inspection of large amounts of video files of learners' productions or in vivo interaction with small groups of students, while also lacking both inter- and intra-instructor consistency and objectivity in grading [3, 4]. For example, at the Special Education Department at University of Thessaly (UTH-SED), the end-of-semester evaluation of L2 learners of Greek SL (GSL) that are enrolled in the corresponding

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Table 8 Subjective evaluation comments returned by 16 evaluation participants (in addition to the questionnaire ratings) in the SL-ReDu system evaluation. Comments in bold will lead to improvements in the human-computer interface of the SL-ReDu system

Subjective evaluation comments
"Easy to manage application with a variety of exercises and a very friendly environment."
"I think this is a very pleasant platform that will help students who want more practice and contact with GSL outside the UTH-SED course."
"The platform is very good and gives us the ability to practice and fill any gaps we may have."
"The platform is quite supportive and enables practice."
"It was a pleasant and unique experience."
"Very nice experience; it helps you a lot."
"It was an interesting experience. The platform is useful and easy to use."
"It was a pleasant experience that I would try again."
"Great program, easy to use and simple. **Maybe it would be better to not scroll down to the page bottom to view the exercise response.**"
"I liked the platform functionally. **Some points need a better design. The numbering 1/6 is placed on the bottom right, while personally I was looking for it between the navigation arrows where there is the exercise indication.**"
"The platform seems pretty easy to use, **however when I stood in front of the camera the system could not detect my face. I made several attempts, but only in 1-2 cases it detected me.**"
"**Letter "E" was not distinct enough as rendered in the fingerspelling signing section.** The environment was very friendly. **The time was not clear enough as it was confused with the number of exercises.**"
"**Fingerspelled letter "II" needs to be corrected. Exam time is too long. Reduce the exercises from 50 to 25 in the general perception exam.**"
"**I would like more colors in the main menu, where we select the sections. Also, when it shows me the correct or incorrect answer, I would like the box to turn green or yellow respectively.**"
"**Some videos play in low quality.**"
"**"Numbers → Numbers 1–10,000 → Summarization". It is not clear which button to click on. I would have liked exercise descriptions. Images accompanying the exercises are unnecessary. Numbers should be included in the "Thematic Vocabulary" menu tab.**"

system, overviewing its built-in interface, linguistic content, and architecture design. Most importantly, we present the GSL recognizer that is integrated to the prototype, and which is capable of recognizing isolated signs within a small vocabulary and continuous fingerspelled letter sequences. In addition, we provide comparative evaluation results of the developed recognition models against state-of-the-art SLR approaches. In particular, the experimental results demonstrate that our recognition module performs well under a signer-independent framework in non-ideal visual settings, outperforming alternative architectures that rely on skeletal, appearance, and motion features. Finally, we present the evaluation campaign of the prototype, discussing results concerning objective assessments of the GSL production aspects of the system, as well as a subjective assessment of the entire platform based on an appropriate questionnaire. The findings of the evaluation can be regarded as very satisfying, validating our approach and the viability of the system design. A larger evaluation campaign is planned in future concerning the next version of the SL-ReDu prototype currently under development, aiming to facilitate significantly richer GSL material and enable continuous GSL production assessment.

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Author Contributions All authors contributed equally.

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Declarations

Conflict of interest There are no conflicts of interest.

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Figure 1: The SL-ReDu publication in the open-access journal *Universal Access in the Information Society* of Springer. **Left**: The first page of the article; **right**: the article page stating the funding agency (H.F.R.I.) and the open-access nature of the publication.

3 The SL-ReDu Presentations During Y3

Six of the aforementioned conference publications (seven in total) have been presented during Y3 of the project at the corresponding conferences. Note that the second publication of the Section 2 bullet list will be presented at INTERSPEECH'23 slightly beyond the end of the project (M44). From these seven presentations, three were made virtually (due to the corresponding conferences being virtual-only or of a hybrid format), whereas the remaining five on-site (live, in person).

The summary of the paper presentations follows:

- August 2023: **G. Potamianos** will present in-person at the *Conference of the International Speech Communication Association (INTERSPEECH'23),* in Dublin, Ireland, the second paper in the bullet list of Section 2.
- July 2023: **G. Sapountzaki** presented virtually at the *International Conference on Education and New Learning Technologies (EDULEARN'23)* the third paper in the bullet list of Section 2.
- June 2023: **E. Efthimiou** presented in-person at the *International Conference on Acoustics, Speech and Signal Processing Workshops (ICASSPW'23) – SLTAT 2023: Eighth International Workshop on Sign Language Translation and Avatar Technology*, in Rhodes, Greece, the fourth paper in the bullet list of Section 2.
- June 2023: **G. Potamianos** presented in-person at the *International Conference on Acoustics, Speech and Signal Processing (ICASSP'23)*, in Rhodes, Greece, the fifth paper in the bullet list of Section 2.
- July 2022: **G. Sapountzaki** presented virtually at the *International Conference on Education and New Learning Technologies (EDULEARN'22)* the sixth paper in the bullet list of Section 2.
- June 2022: **E. Efthimiou** and **S.-E. Fotinea** presented in-person at the *7th International Workshop on Sign Language Translation and Avatar Technology: The Junction of the Visual and the Textual: Challenges and Perspectives* (Satellite Workshop to the *Language Resources and Evaluation Conference (LREC'22))*, in Marseille, France, the seventh paper in the bullet list of Section 2.
- May 2022: **G. Potamianos** and **K. Papadimitriou** presented virtually at the *International Conference on Acoustics, Speech and Signal Processing (ICASSP'22)* the eighth paper in the bullet list of Section 2.

Concerning the virtual presentations, the ICASSP'22 one was made online via the conference-organized zoom interface based on a pre-recorded presentation video / voice-over of slides, with the presenters responding to audience questions both on-line and off-line. On the other hand, the EDULEARN'22 and EDULEARN'23 conference paper presentations was uploaded in the form of a slide presentation that was available to the conference participants in an off-line asynchronous mode. The rest of the presentations were given in-person in a poster format (some accompanied by a one-slide "pitch" presentation), thus allowing plenty of interaction with conference participants interested to learn more about the SL-ReDu work. Note that all such presentation material can be retrieved from the SL-ReDu website (`URL: https://sl-redu.e-ce.uth.gr/project_news`).

Overall, an effort has been made to produce all presentations following a uniform style and employing a consistent template. In the case of virtual presentations based on slides, all slides were bearing the logo of H.F.R.I. and the final slide including the acknowledgements text requested by H.F.R.I. in the implementation guide of the funding action. An example of such format is shown in Figure 2, where the first and last slide of the EDULEARN'22 presentation are depicted. Further, an example of a poster

presentation (at ICASSPW-SLTAT'23) is provided in Figure 3, accompanied in Figure 4 by a picture showing an example of interaction with conference participants.

Figure 2: The first slide (**left**) and last slide (**right**) of the SL-ReDu presentation at EDULEARN'22, showcasing the general presentation style adopted and the acknowledgement to H.F.R.I. funding.

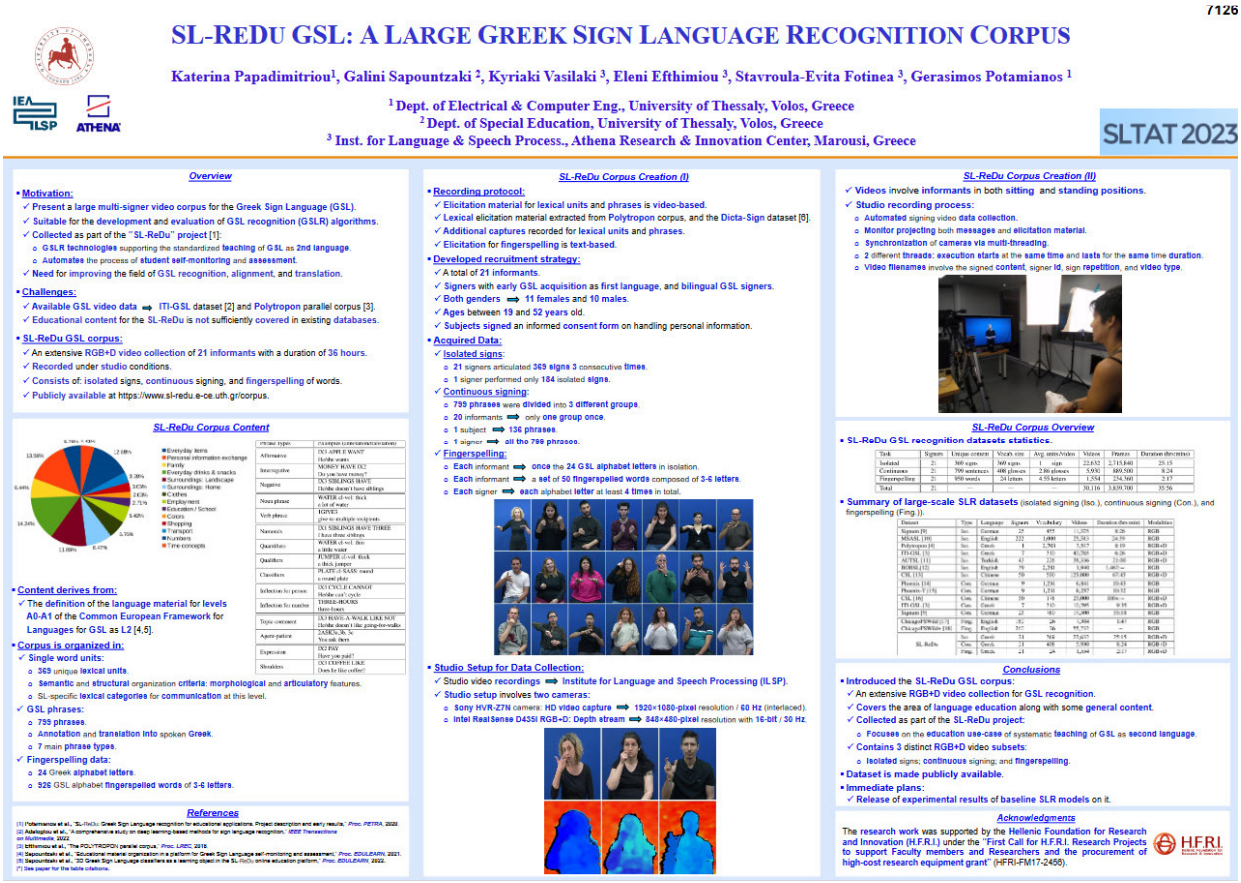

Figure 3: The SL-ReDu poster presentation at ICASSPW-SLTAT'23, showing the general poster style adopted and the acknowledgement to H.F.R.I. funding.

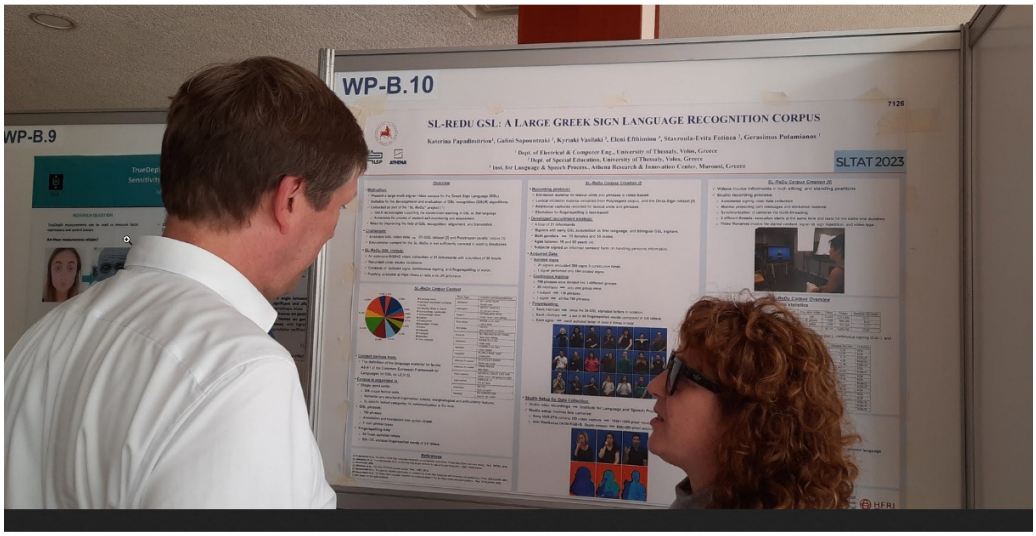

Figure 4: Interaction during the SL-ReDu poster presentation at ICASSPW-SLTAT'23, showing S.-E. Fotinea (AthenaRC) discussing with Thomas Hanke (University of Hamburg).

4 Additional Y3 Dissemination and Educational Activities

In addition to the above activities, the following two dissemination actions have taken place:

- 8 June 2022: The SL-ReDu project was presented at an education event that was organized by UTH-SED at their premises in Volos, Greece, in conjunction with the European Centre for Modern Languages (ECML) and the Directorate of European and International Affairs of the Greek Ministry of Education and Religious Affairs. For this purpose, a video was recorded that was played during the event. The video is available on the SL-ReDu website (URL: https://sl-redu.e-ce.uth.gr/project_news).
- 24 September 2022: The SL-ReDu project and prototype was presented at the DEAFestival'22 (URL: https://www.omke.gr/deafestival-2022/) held in Athens, Greece at the premises of the National Institute of the Deaf. Two pictures of the event are provided in Figure 5.

In both events, SL-ReDu brochures were also available for the participants, and many discussions took place between project personnel and interested stakeholders.

Further, SL-ReDu personnel (E. Efthimiou and S.-E. Fotinea) has been actively involved (as members of the organizing committee) in two editions of the established SLTAT workshop series (Sign Language Translation and Avatar Technology). Specifically the following two events were held:

- 24 June 2022: Seventh International Workshop on Sign Language Translation and Avatar Technology: The Junction of the Visual and the Textual: Challenges and Perspectives as a Satellite Workshop to the Language Resources and Evaluation Conference (LREC'22) (URL: sltat.cs.depaul.edu/sltat_2022.htm).
- 9 June 2023: Eighth International Workshop on Sign Language Translation and Avatar Technology as a Satellite Workshop to the International Conference on Acoustics, Speech and Signal Processing (ICASSP'23) (URL: sltat.cs.depaul.edu/sltat_2023.htm).

In both events, in addition to SL-ReDu paper presentations, SL-ReDu brochures were available for the participants, and many discussions took place between project personnel and interested stakeholders, paving the way for project exploitation opportunities, as also discussed in D6.5 [3].

Figure 5: Presentation of the SL-ReDu project and system at the DEAFestival'22 in Athens, Greece.

Further, supporting advanced education in the SL-ReDu research areas, a number of student Theses, ongoing or completed, are related to the project. Specifically, the following Ph.D. Thesis is very close to its completion:

- Katerina Papadimitriou, *A Multimodal Approach to the Automatic Recognition of Sign Language and its Application to a Greek Sign Language Education Platform*, supervised by G. Potamianos [expected completion: November 2023];

the following two Master Theses are ongoing:

- Vasilia Sirianou, *Language Data Organization Based on WordNet*, supervised by E. Efthimiou [expected completion: May, 2024];
- Konstantinos Moschos, *Embedded System Implementation of a Fingerspelling Recognizer of Greek Sign Language*, supervised by G. Potamianos [expected completion: February 2024];

the following three Diploma Theses have been completed during Y3:

- Alexandros Dimos, *Tracking and Recognition of Fingerspelling from Videos*, supervised by G. Potamianos [completed: July 2022];
- Angelos Pantopoulos, *A Computer Vision System for Automatic Evaluation of Greek Sign Language Fingerspelling Proficiency*, supervised by G. Potamianos [completed: September 2022];
- Georgios Charamis, *An Application for Converting Sign Language Fingerspelling to Speech*, supervised by G. Potamianos [completed: July 2023];

and an additional Diploma Thesis is close to its completion:

- Anastasia Psarou, *Fingerspelling Recognition in the Greek Sign Language using Human Skeletal Features and Pose Features*, supervised by G. Potamianos [expected completion: September 2023].

Finally, we have redesigned the project flyer and poster, capturing more up-to-date information of the SL-ReDu project, in order to further facilitate its dissemination at events such as the DEAFestival, appropriate conferences, and at the partners' premises. For example, the new poster is shown in Figure 6 in the next page.

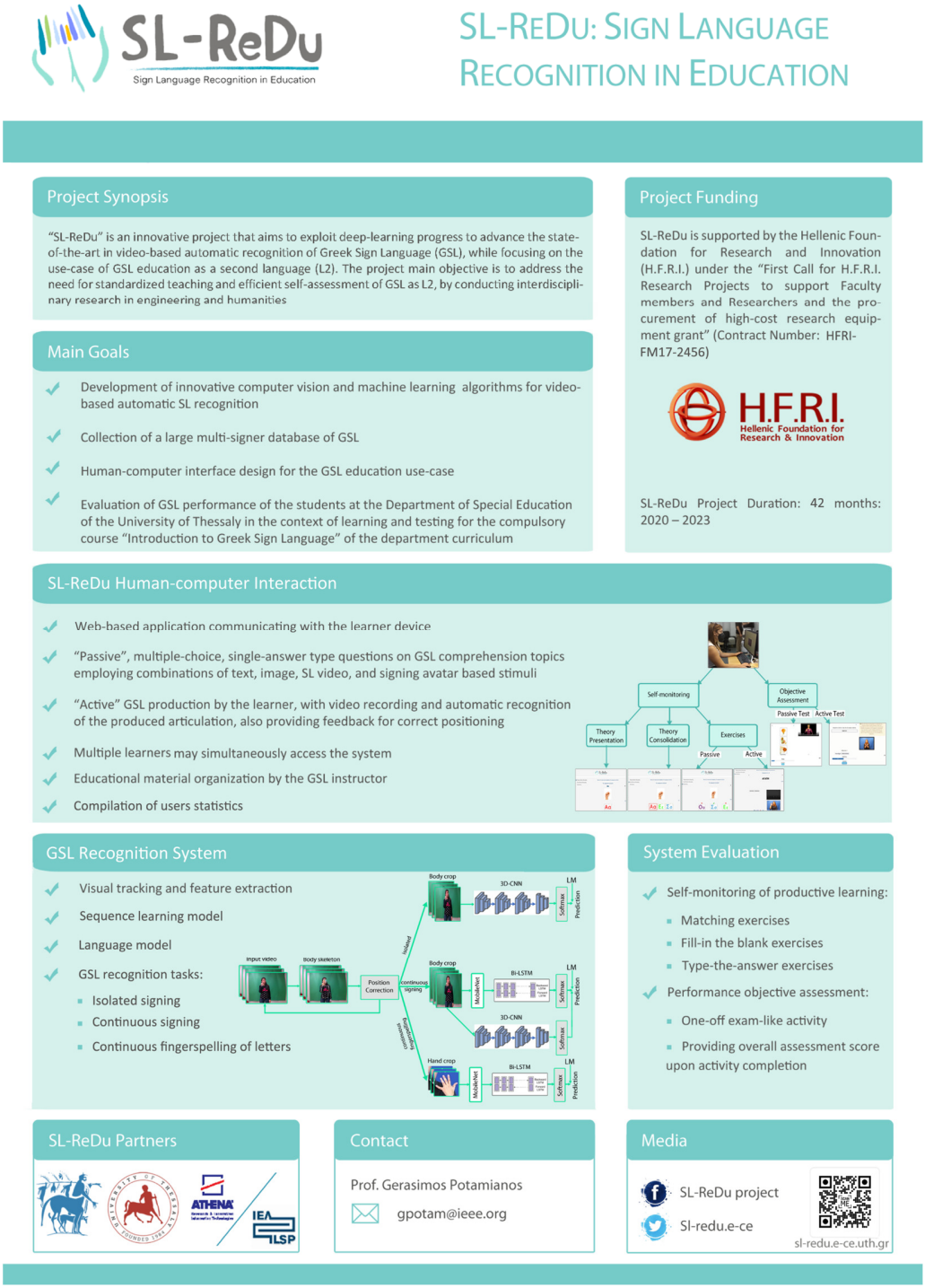

Figure 6: The redesigned project poster for further project dissemination.

5 Future Dissemination Plans

The SL-ReDu partners plan to continue dissemination activities beyond the project's end in a series of events that attract heavy interest by the general public as well as some of the project stakeholders and policy makers. Among those, we plan to participate in September 2023 at the DEAFestival in Larissa, Greece (URL: https://www.omke.gr/deafestival-2023/).

Following on the footsteps of our Y1-Y3 publications, we plan to submit articles to at least one conference in late 2023 / early 2024, as well as to one journal, based on the Ph.D. Thesis work of Katerina Papadimitriou.

6 Conclusions

In this deliverable, we presented our dissemination activities during the third (final) year of the SL-ReDu project, primarily involving conference paper publications and presentations, as well as an open-access journal publication, some additional dissemination work, and student supervision in their thesis work on the project challenging topics. It's worth noting that the SL-ReDu project has resulted to a total of 16 publications during its life-span (see also [1], [2]). Finally, in this deliverable we briefly outlined our plans for possible future dissemination activities, beyond the project's end.

References

[1] G. Potamianos, K. Papadimitriou, E. Efthimiou, S.-E. Fotinea, P. Maragos, and G. Sapountzaki, "D6.1: Publicity and dissemination report for Y1, including project website," *Tech. Report, SL-ReDu Project Deliverable*, Volos, Greece, 2021.

[2] G. Potamianos, K. Papadimitriou, E. Efthimiou, S.-E. Fotinea, P. Maragos, and G. Sapountzaki, "D6.2: Publicity and dissemination report for Y2," *Tech. Report, SL-ReDu Project Deliverable*, Volos, Greece, 2022.

[3] E. Efthimiou, S.-E. Fotinea, G. Sapountzaki, and G. Potamianos, "D6.5: Updated version of exploitation plan and exploitation actions," *Tech. Report, SL-ReDu Project Deliverable*, Volos, Greece, 2023.