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Pedagogical approaches for e-assessment with authentication and authorship verification in Higher Education

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Abstract

Checking the identity of students and authorship of their online submissions is a major concern in Higher Education due to the increasing amount of plagiarism and cheating using the Internet. The literature on the effects of e-authentication systems for teaching staff is very limited because it is a novel procedure for them. A considerable gap is to understand teaching staff' views regarding the use of e-authentication instruments and how they impact trust in e-assessment. This mixed-method study examines the concerns and practices of 108 teaching staff who used the TeSLA—*Adaptive Trust-based e-Assessment System* in six countries: the UK, Spain, the Netherlands, Bulgaria, Finland and Turkey. The findings revealed some technological, organisational and pedagogical issues related to accessibility, security, privacy and e-assessment design and feedback. Recommendations are to provide a FAQ and an audit report with results, to raise awareness about data security and privacy, to develop policies and guidelines about fraud detection and prevention, e-assessment best practices and course team support.

Introduction

One of the main concerns for the adoption of e-assessment is to ensure that the person who performs the assessment is the correct claimant (authentication) and to demonstrate that the work performed is original (authorship) (Noguera, Guerrero-Roldán, & Rodríguez, 2017; Okada, Mendonca, & Scott, 2015; Okada, Whitelock *et al.* 2018). A growing body of literature has explored and recommended the use of security mechanisms to identify students and detect illegitimate behaviours in e-assessment (Harmon, Lambrinos, & Buffolino, 2010; Osman, Salim, & Abuobieda, 2012; Simon *et al.*, 2013; Watson & Sottile, 2010).

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Practitioner Notes

What is already known about this topic

- Checking the identity of students and authorship of their online submissions is a major concern in Higher Education.
- A growing body of literature recommended the use of security mechanisms to identify students and detect illegitimate behaviours in e-assessment.
- The relation between pedagogical approaches and e-assessment supported by e-authentication and authorship verification is under-explored.

What this paper adds

- Teaching-learning process with the support of e-authentication and authorship verification instruments integrated at the course design stage.
- E-assessment activities' characteristics identified to support face recognition, voice recognition, keystroke dynamics, forensic analysis and plagiarism detection.
- Seven recommendations to help teaching staff with e-assessment supported by e-authentication and authorship verification.

Implications for practice and/or policy

- Increasing the awareness of data security and privacy among all end-users will be important to enhance the trust of the e-assessment system with e-authentication and authorship verification.
- Universities must develop and share best practices for verifying fraud supported by the e-assessment system based on combined e-authentication and authorship verification instruments.
- Universities should support course teams to plan useful activities and assessment tasks with e-authentication and authorship verification instruments.

According to European research on the impact of policies for plagiarism in Higher Education (IPPHEAE, 2013), internet usage is considered as one of the catalysts for cheating. Moreover, no simple solutions have been found to tackle this problem (Bermingham, Watson, & Jones, 2010; Usoof, Hudson, & Lindgren, 2014). In order to reduce academic malpractice in online programmes, the authentication of student work through the use of digital identities has become increasingly important for universities that offer online and blended courses (Ardid, Gomez-Tejedor, Meseguer-Duenas, Riera, & Vidaurre, 2015; Chew, Ding, & Rowell, 2015). E-assessment systems are perceived as secure and appropriate when the instruments successfully identify and authenticate the examinee (Apampa, Wills, & Argles, 2010; Gao, 2012; Karim & Shukur, 2016).

This paper focuses on the use of these types of e-authentication and authorship instruments by seven pilot institutions involved in the EU-funded *TeSLA* project—*Adaptive Trust-based e-Assessment System for Learning* (http://tesla-project.eu). The TeSLA system combines the instruments developed by several institutions and companies that are part of the consortium. Biometric instruments are used to authenticate students, while the instruments that analyse text are employed in verifying authorship. Some textual analysis instruments like writing style (Forensic) analysis can also be used for authentication purposes. The instruments are described in detail below (Knuth, 2016). Apart from plagiarism detection, these instruments require a sample to be created separately by each student as a learner model to be compared with their e-assessment activities.

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Biometrics

- *Facial Recognition (FR):* compares the face and facial expressions using images (minimum resolution of 640 px × 480 px) and videos of at least 10 seconds with the learner model.
- *Voice Recognition (VR):* compares voice structures with the learner model. The set of speech samples must have a minimum resolution of 16 kHz.
- *Keystroke Dynamics (KD):* compares the rhythm and speed of typing when using the keyboard with the learner model. At least 30 samples have to be collected that must contain dwells and flights, which must be extracted from 125 consecutive pressed keys.
- *Face presentation attack detection (FPAD):* detects presentation attacks to the face recognition instrument. It expects a real person in front of the camera and not an image. The student must be close to the camera with a minimum distance of 50 pixels between the centre of the eyes.
- *Voice presentation attack detection (VPAD):* detects attacks in the voice presentation. It expects a real person talking and not an audio file. The student's uncompressed recorded audio file must have a minimum resolution of 16 kHz.

Textual analysis

- *Plagiarism detection (PL):* detects similarities (word-for-word copies) between a given set of text documents created by students using text matching. The instrument supports common text, word-processor and PDF formats. This instrument does not compare the given set with external content on the internet.
- *Forensic Analysis (FA):* compares the personal writing style to the learner model. The user model is updated over time with submission of new documents.

The TeSLA instruments (Figure 1) can be integrated into any Institutional Virtual Learning Environment (VLE). The learner and teacher user interfaces are implemented via an LTI plugin. Three different versions of the TeSLA system have been tested in the project. The current study reports on the second version that was implemented during the spring semester of 2016/2017 academic year.

This study is based on Responsible Research and Innovation (RRI) approach, which refers to the transparent and interactive process for aligning scientific innovation to the values, needs and expectations of the society (EC, 2017; Owen, 2015; Von Schomberg, 2011). This work is part of a research programme whose aim is to examine how technology-enhanced assessment (TEA) can address the needs and expectations of educational communities during the development of the TeSLA system. This particular RRI study focuses on teachers' perceptions of e-assessment with e-authentication and authorship verification. It analyses teaching staff concerns and practices with assessment activities combined with e-authentication of students' identity and authorship verification, including students with Special Educational Needs and Disabilities (SEND). Findings on teachers' acceptability and desirability of the innovation process including its sustainability

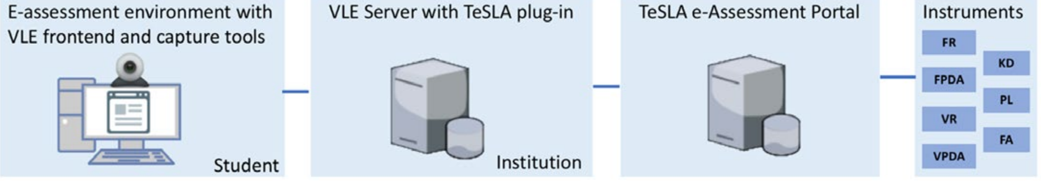

Figure 1: TeSLA architecture (Knuth, 2016)

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based on pedagogical approaches will be of interest for higher education institutions, course developers, pedagogical teams and policy makers.

Opportunities afforded by TEA

A recent research review (Timmis, Broadfoot, Sutherland, & Oldfield, 2016) presents seven features of TEA approaches. It highlights the critical role of TEA, which offers many potentially creative opportunities for innovation and for rethinking assessment purposes. Digital media provide students with new opportunities for representing knowledge and skills. Students can benefit from new ways to record achievement, such as, open badges and awards from gaming environments (Law, 2016). However, there are also various concerns, such as ethical issues and the implications for general data protection (GPDR) and ownership of making, mixing and publishing media online and consent about how such data should be collected, used and stored. Another issue is social exclusion, for example, students might not feel comfortable with the assessment environment when they do not feel safe enough in case of failure and overly concerned with the consequences.

There is a lack of literature related to pedagogical recommendations for e-assessment with instruments for e-authentication and authorship verification. In the TeSLA project, the process of integrating these instruments starts at the course design stage (Figure 2).

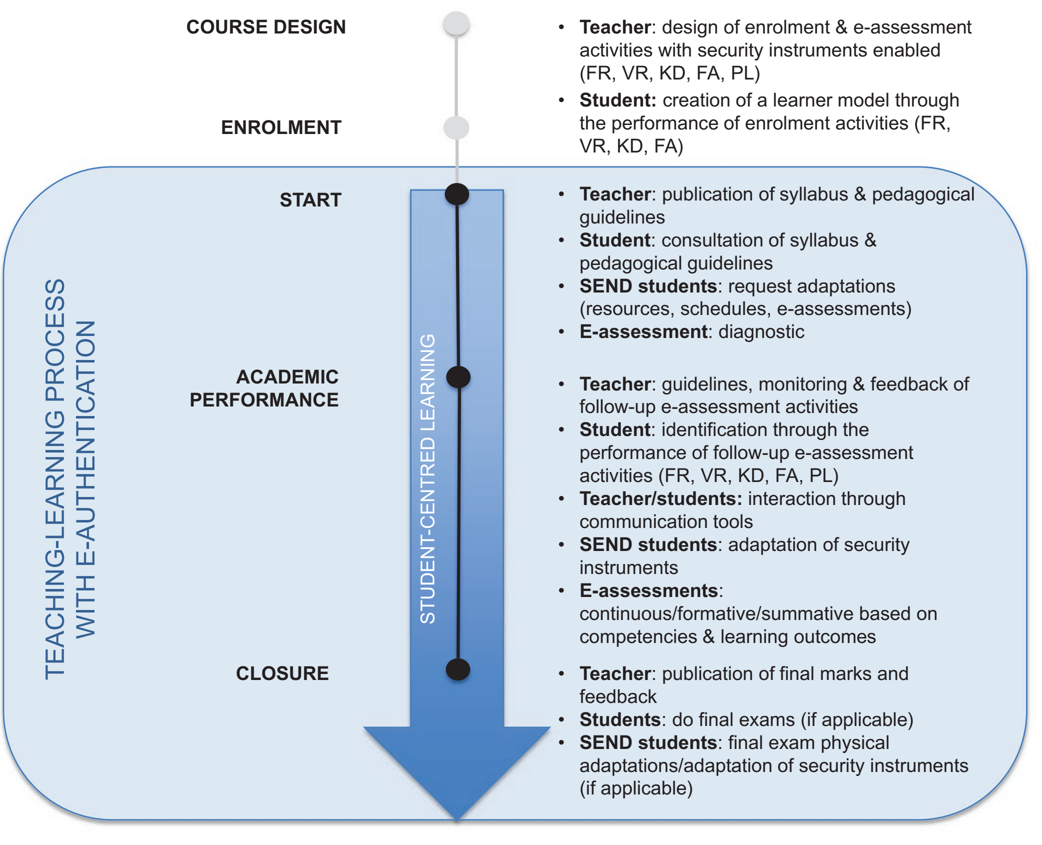

Figure 2: Teaching-learning process with the support of e-authentication and authoring instruments

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The teacher redesigns, or creates new e-assessment activities, where the security instruments are enabled. Two types of activities are necessary: enrolment and real. The *enrolment activities* are used to create a learner model (a biometric model) that is later used as a reference for user authentication in subsequent real activities. They are activities with non-grading purpose that serve for user registration. The *real e-assessment activities* aim to authenticate students and validate the authorship of their work and may have grading purpose. The enrolment activities have to be performed prior to the real e-assessment activities.

The most widespread classification of learning activities is Bloom's taxonomy which differentiates between knowledge, comprehension, application, analysis, synthesis and evaluation skills (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1956). Several authors have redefined these categories by incorporating new activities and tools related to digital resources (Carrington, 2016; Churches, 2008; Schrock, 2013).

The specific classifications regarding e-assessment activities include questions (eg, closed, open, multiple-choice, matching, ordering), e-portfolios, essays, online discussions, concept maps, personal response systems, badging, online role playing or scenario-based activities (Guàrdia, Crisp, & Alsina, 2017; Manoharan, 2016; Stödberg, 2012; Trumbull & Lash, 2013). A recent study proposes a new classification of e-assessment activities organised into five competences: (1) ability to search for, process and analyse information, (2) ability to apply acquired knowledge, (3) ability to use language to communicate successfully, (4) ability to create learning products in diverse formats and (5) ability to apply knowledge in real or simulated scenarios (Guerrero-Roldán & Noguera, 2018). Following the approach of classifying the activities based on the abilities they help to develop, in the context of the TeSLA project, e-assessment activities are organised into three categories related to what types of skills are being tested:

1. *Selection:* students select an answer (eg, a correct answer from a list, a match or an adequate next step in a procedure).
2. *Creation*: students create an answer or product (eg, an answer to an open question, a report, a table or an image).
3. *Performance:* students perform/enact/demonstrate attainment of learning outcomes (eg, giving a presentation, taking part in a role play, game or simulation, carrying out a laboratory practical or an internship).

These activities can be delivered in various formats. For instance, a text may be typed or generated using speech to text software, a performance may be delivered "real-time" or submitted as a video and/or voice recording.

Methodology

The TeSLA system is being designed and refined following a cyclical process of improvement based on the quantitative and qualitative data collected and analysed with mixed-methods from three sets of pilots. This paper focuses on the experience and data gathered from the second pilot that took place between February and June 2017 within the context of seven universities (including face-to-face, blended and online modes of delivery) in six countries. These universities were: Anadolu University (AU) in Turkey, the University of Jyväskylä (JYU) in Finland, Open Universiteit (OUNL) in the Netherlands, Open University (OU-UK) in the United Kingdom, the University of Sofia (SU) and (Technical University of Sofia) TUS both in Bulgaria and Open University of Catalonia (UOC) in Catalunya.

To understand the various affordances and issues raised above and to contribute to the refinement of the TeSLA e-authentication and authoring instruments, we investigated teaching staff' views about the TeSLA system with respect to the following research questions:

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- (RQ1) What are the pedagogical approaches used for implementing the TeSLA e-authentication and authoring instruments for e-assessment?
- (RQ2) How accurate are TeSLA instruments in identifying plagiarism and cheating?
- (RQ3) What are the teaching staff opinions about the use of the TeSLA e-authentication and authoring instruments for e-assessment?
- (RQ4) What are the teaching staff recommendations for the use of the TeSLA instruments with students?

Context and participants

The participants in this study were teaching staff of undergraduate and postgraduate courses from a range of fields of study. Table 1 illustrates the characteristics of a total of 113 courses from the seven pilot institutions participating in the pilot.

The five TeSLA instruments (FR, VR, KD, FA, PL) were employed in these courses. The choice of instruments was based on the assessment contexts and feasibility of use according to the assessment activity. Table 2 illustrates the number of students using the TeSLA instruments and Table 3 shows the total set of samples gathered and analysed by the TeSLA system during the enrolment and assessment activities.

The procedures for data collection

Teaching staff completed the following steps during the course of the TeSLA pilot:

- *Course design:* design and implement an e-assessment with instruments for students. For instance, typing or choosing answers in quizzes or online text submissions (FA, KD and PL), performing a presentation (FR, VR), creating artefacts (FR, VR, KD, FA and PL) or uploading documents in assignment (PL, FA).

Table 1: Characteristics of the courses participating in the pilot

Characteristics	*Values*	*%*
Mode of delivery	Blended	48
	Online and distance	52
Language of the course	Bulgarian	15
	Catalan and Spanish	14
	English	28
	Finnish	19
	Turkish	20
Course level	Continuing professional development (CPD)	1
	Post-graduate	11
	Undergraduate	71
	Undergraduate & CPD	16
	Other or missing	1
Field of study	Arts and Humanities	10
	Social and Legal Sciences	66
	Sciences	6
	Health sciences	2
	Engineering and architecture	15
	Other or missing	1

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Table 2: Number of students who used each instrument per pilot institution

	Institutions							
Instruments	*AU*	*JYU*	*OUNL*	*OUUK*	*SU*	*TUS*	*UOC*	*Total*
(FR)Face recognition	1443	10	14	–	262	402	503	2634
(VR)Voice recognition	175	10	8	–	63	200	437	893
(KD)Keystroke dynamics	191	87	7	382	61	249	500	1095
(FA)Forensic analysis	72	103	32	–	125	47	486	865
(PL)Plagiarism detection	70	80	132	266	125	89	455	951
Total of students	1951	280	159	648	505	506	882	4931

Table 3: Samples from seven institutions analysed by the TeSLA system

	Audio	*Text document*	*Keystroke*	*Video*
Valid enrolment samples	10,830	10,228	19,021	6281
Valid verification samples from assessment activities	4159	993	7843	3894

- *Enrolment*: provide guidelines for students to create a baseline for the instruments used during the real e-assessment activities. This procedure provides initial data for the system to compare against during the e-authentication and authorship checking.
- *Pre-questionnaire*: complete a 20-question questionnaire about their demographics, views about plagiarism and cheating, their opinions about e-authentication and authorship checking instruments, data security, data privacy and trust.
- *Post-questionnaire:* complete a 15-question post-questionnaire about their experience with the TeSLA system after using it with students, with similar questions of the pre-questionnaire.
- *Focus group:* attend 40-minute session online or face-to-face to provide detailed views.

One representative from each pilot institution was in regular communication with teaching staff, to support them and gather data about the courses and the pilot progress recorded in an online database.

A representative sample of 108 teaching staff in terms of gender, age and occupation participated in this study (Table 4). Response rate for the pre-pilot questionnaire was 84% ($N = 78$) and 45% ($N = 42$) for the post-pilot questionnaire. This questionnaire included a question for willingness to participate in the focus group. From these, 35 interviewees participated in representative focus group sessions organised by the seven pilot countries (Table 5).

Data analysis

In order to develop a unified approach to planning, implementing and reporting the outcome of the focus group sessions across the seven countries, co-authors developed the focus group guidance and a template to support cross-national data analysis of qualitative data from the interviewees and quantitative data from questionnaires' respondents as well. From a pre-pilot study at the beginning of the project the categories Technical, Organisational and Pedagogical emerged, comprising eight themes (system interface, TeSLA instruments, real-time feedback, usability, accessibility, security and privacy, fraud detection and pedagogy and assessment) (Figure 3).

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Table 4: Teaching staff demographics from respondents to pre-pilot questionnaire (N = *78*)

Items	*Values*	N	%
Gender	Prefer not to say	3	4
	Female	45	58
	Male	30	38
Age	Prefer not to say	2	3
	From 31 to 40 years old	25	32
	From 41 to 50 years old	33	42
	51 years or over	18	23
Occupation	Course designer	37	47
	Students' assessor	31	40
	Course instructor	69	88
	Other	2	3

Table 5: Teaching staff participants in focus groups (N = 35)

		AU	*JYU*	*OUNL*	*OUUK*	*SU*	*TUS*	*UOC*
Total	Teaching staff	4	5	4	4	7	7	4
Gender	Female	2	4	2	2	3	5	2
	Male	2	1	2	2	4	3	2
Role	Course designer	1	5	4	2	6	8	3
	Course Instructor	2	5	4	3	6	8	1
	Students assessor	0	5	4	3	6	8	0
	Other	1	0	0	0	1	0	0

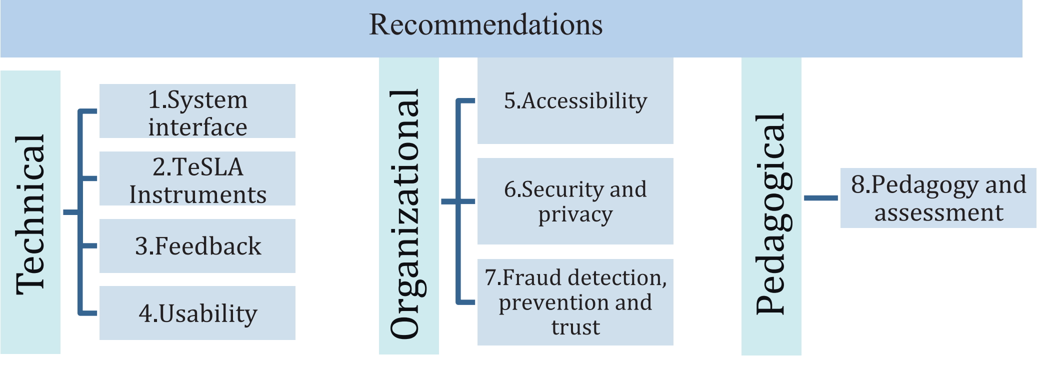

Figure 3: Categories for data analysis of e-assessment with e-authentication instruments

A deductive approach was implemented for data analysis to identify pattern matching (Hyde, 2000). The research questions and conceptual categories were used to group the data and detect the main findings across the seven institutions. Questionnaires' results were analysed based on the number of respondents and presented as a percentage.

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Findings

Pedagogical approaches for teaching staff interested in TeSLA (RQ1)

The underlying TeSLA educational assessment model describes an "assessment" as an assembly of one or more "activities" designed to measure "learning outcomes" with the aim to establish (collect evidence of) a person's competences (cognitive and non-cognitive traits) at a particular moment in time. The response to an activity ("activity response") can be of various kinds (ie, the learner has to select, create or perform). An assessor applies "assessment criterion" defined in connection with an activity to the activity response of a learner or a group of learners. The response format comprises: mouse click, text, sound, image or programming code. The assessor determines the result (eg, mark and feedback).

To answer the first question of this study, the various types of e-assessment activities descriptions used in the pilot have been categorised according to this model. Based on the literature and the assessment scenarios of the pilot courses, Table 6 presents a set of e-assessment activities that can be used for e-assessment. Activities are grouped according to type of response and Bloom revised taxonomy (Krathwohl, 2002). For each activity, the applicable instrument is indicated.

Altogether a full range of pedagogical activities linked to Bloom's taxonomy could be tested with the TeSLA instruments but not all authentication tools could be applied to all types of activities. Careful selection was required. Table 7 presents the characteristics of the e-assessment activities in the courses.

In general, the e-assessment activities represent a balanced sample in terms of assessment purposes: formative (62%), summative (23%) and diagnostic (4%). The majority of activities have been designed to be conducted at home (85%), in an unsupervised way (85%) and individually (93%). The response type most used has been the creation of an answer or product (73%) in text format (61%).

TeSLA Accuracy in detecting plagiarism and cheating (RQ2)

A large amount of data from 4931 students (Table 2) was gathered during the pilot to examine the accuracy of the TeSLA instruments. The accuracy value was computed for each instrument as the fraction of samples classified correctly as "true positive" and "true negative" over the total samples used in the tests (including non-processed samples). Findings (Table 8) show that some instruments, like PL (plagiarism), whose data (text documents) could be easily interpreted by computers, performed well. Instruments, that have to process more complex data, such as video and audio, showed a lower rate of accuracy. Therefore, teaching staff will need to invest more time into checking result of these instruments including the cases of false positive and false negatives.

Accuracy data were not yet available to teaching staff during the pilot. However, the latest version of TeSLA system indicates results as illicit, not sure or licit and offers an audit data report to assist teachers in interpreting the instrument results.

Teaching staff opinions about the use of TeSLA (RQ3)

Data from the teaching staff post-questionnaire show that the majority of partner universities' staff considered e-authentication relevant and agreed that "their university is working to ensure the quality of the assessment process" (AU, JYU, SU and TUS 100%, UOC 91% and OUUK 75%). They also "trust an assessment system in which all assessment occurs online" (JYU 100%, SU 83%, AU and OUUK 75%, UOC 69% and TUS 50%).

In addition, respondents indicated that the main advantages of e-assessment with e-authentication based on educators' views were:

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Table 6: Potential E-assessment activities in conjunction with face recognition, voice recognition, keystroke dynamics, forensic analysis and plagiarism detection

TeSLA	*Bloom taxonomy*	*Online activities*	*FR*	*VR*	*KD*	*FA*	*PL*
Selection	Recall facts, concepts	Complete quiz-based exams	✓				
		Complete questionnaires with multiple choice and students can use voice	✓	✓			
Performance	Understand, explain ideas or meanings	Complete questionnaire with open questions (250 characters)	✓		✓	✓	✓
		Participate in a discussion forum, blog notes, or learning diary	✓		✓	✓	✓
		Participate in a web conference with a discussion chat	✓	✓	✓		
	Apply, use knowledge in new situations or for inquiry-based learning or problem solving	Give an oral presentation	✓	✓			
		Participate in a game or simulation task (with voice)	✓	✓			
		Take part in a role-play (with voice)	✓	✓			
	Analyse (compare, connect ideas), evaluate (justify decisions)	Carry out a practice in a laboratory (with voice explanation)	✓	✓			
		Execute data analysis using Excel or software (with voice explanation)	✓	✓			
		Solve mathematical problems (using text and/or voice explanation)	✓	✓	✓		
Creation	Create Produce original work	Develop a multimedia presentation a multimedia presentation or video clip (with voice slides)	✓	✓			
		Elaborate a poster or info-graphic about a research topic (with voice)	✓	✓			
		Develop programming code	✓		✓		
		Elaborate academic paper (essay) or report about a research theme or final written assignment	✓		✓	✓	✓

- "To save time in commuting" (all institutions: 50%–100%).
- "To prove originality of the students' work" (SU: 83%, OUUK: 75%, JYU: 60%, AU: 50%, TUS: 50%).
- "To avoid face-to-face assessment" (SU: 67%, UOC: 66%, AU: 50%).
- "To better adapt assessment to students' needs" (OUUK: 75%, AU: 50%).

Based on the pre-pilot questionnaire data, most of staff members from the universities confirmed that students occasionally cheat in their courses (OUUK: 75%, UOC: 56%, JYU: 56%, OUNL: 50%

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Table 7: Characteristics of e-assessment activities (N = 108)

Characteristics	*Values*	*%*
Assessment purpose	Formative	62
	Summative	23
	Diagnostic	4
	Other or missing	10
Location	At home	85
	At university	15
Monitoring	Supervised	15
	Unsupervised	85
Individual or collaborative work	Individual	93
	Collaborative	6
	Individual and collaborative	1
Response type	Select answer	17
	Create answer or product	73
	Perform/enact/demonstrate	10
Response format	Mouse click	14
	Text	61
	Sound (oral input)	8
	Image (picture, video)	17
	Programming code	0

Table 8: Accuracy of TeSLA system instruments based on the samples of seven institutions

Instrument	*Licit sample correctly identified as licit (TP) (%)*	*Fraudulent sample correctly identified as fraudulent (TN) (%)*	*Fraudulent sample incorrectly identified as licit (FP) (%)*	*Licit sample incorrectly identified as fraudulent (FN) (%)*	*Accuracy*
FR	4.80	47.83	0.46	44.27	54
PL	50.00	45.00	5.00	0.00	95
FA	30.00	50.00	0.00	20.00	80
KD	40.00	50.00	0.00	10.00	90
VR	0.00	48.61	0.00	50.00	49

and SU: 50%). The majority of respondents agreed (more than 90% from all universities) that "It is cheating if a student copy/pastes information from a website in a work developed by him/her without citing the original source." However, these respondents mentioned that they were "not so sure about students who plagiarise when they work together and submit similar work" (SU: 50%, TUS: 43%, UOC: 26%). They also confirmed that "There are clear and specific rules to follow at their institution to deal with cheating" AU (99%), UOC (93%), JYU (89%), OUUK (75%), TUS (71%), SU (50%), OUNL (50%).

However, a significant number of respondents (more than 50%) found that the key disadvantages of e-assessment were:

- "Work overload in performing the assessment activities" (OUUK: 75%, SU: 67%, UOC: 44%).
- "To spend time learning to use new technologies" (OUUK: 75%, JYU: 60%, AU: 50%).

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- “Time overload in assessing the activities,” particularly (AU: 50%).

In addition, data about respondents' views also confirmed a few issues about security and privacy, such as students' resistance in sharing personal data. For example:

- “*Some students were very critical about sharing this kind of personal data.*” JYU
- “*Some students, who used face recognition tool, were asking about who will watch their videos and what the aim of it is.*” SU
- “*Some students asked various questions about data privacy and security by email.*” OUUK

Teaching staff recommendations about the use of TeSLA (RQ3)

Table 9 presents solutions or recommendations for each of the eight themes for technical needs, organisational views and pedagogical issues as voiced by interviewees during the focus group.

In terms of technical needs, most of interviewees considered TeSLA easy-to-use and user-friendly system. However, they would like to obtain more guidance from the system to combine instruments and analyse outcomes in order to use the instruments more effectively.

- “Teachers need to get to know the instruments early enough to be able to plan useful and meaningful activities” (JYU).
- It might be more “effective when at least two instruments are combined” (SU).

The familiarity with instrument and the technical requirements will help teaching staff to support their students.

- “Students who worked with older versions of Office2003 and used Internet Explorer browser had problems with TeSLA” (SU).
- “We ask students to attach charts and images, I am not sure if the authorship can be checked in such cases” (UOC).

Interviewees mentioned that they would like also reports that can be accessed quickly after the activity is completed. They would like to be notified when:

- “Are several faces detected in the camera frame?” (TUS).
- “Cases where the same person performs differently in the enrolment and in other activities” (UOC).
- “What are the procedures when the system does not recognise a student?” (OUUK).

Interviewees also mentioned about mobile devices. Teaching staff will not recommend taking an assessment using mobile phones because the screen is very small. However, if TeSLA can work in mobile devices (such as tablets) they think that this would be very useful because *“students use their voice, camera and fingerprint authentication frequently on their mobile devices*” (OUUK).

In terms of organisational views, some interviewees presented positive comments related to the system that enabled inclusive e-assessment tasks for *special educational needs and disable* students (SEND).

- “SEND students felt a little bit intimidated showing their face and been recorded. However, this system will be very helpful for adapting the assessment to their needs” (UOC).
- “Students can use other programs and browsers/tabs on their computer while completing the exam, their actions during the assessment are not observed” (SU).

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Table 9: Recommendations based on focus group results

Categories	*Themes*	*Solution*	*Remark*
Technical needs	1. System Interface	Guidance	More guidance from the system to combine instruments and analyse outcomes
	2. TeSLA Instruments	Familiarity	Knowledge about the instruments (including technical requirements) early to plan activities
	3. Feedback	Audit report	Audit Reports that can be accessed quickly after the activity including results
	4. Usability	New devices	More flexible options for mobile devices
Organisational issues	5. Accessibility	Inclusive tasks	Adapting different instruments and tasks according to students' special needs
		SEND assistance	Some SEND students had difficulties with the system based on their disability
	6. Security and privacy	Flexibility of e-assessment	TeSLA might support the shift from human invigilated exams to system invigilated exams
		Privacy concerns	Various students felt comfortable by sharing their data but some of them had concerns about their privacy and security
	7. Fraud, prevention and trust	Cheating prevention	An opportunity to limit cheating in the university education
		Fair assessment and accreditation	Convenience and "fair assessment and accreditation of students based on their merits"
		Reliable system	Reliable system will increase the confidence of the institution
Pedagogical aspects	8. Assessment pedagogy	Course design changes	Change in course design required to use TeSLA effectively
		New types of e-assessment	Opportunities of "new kinds of assessments"
		Variety and regularity	More open-ended questions, and variety of types of assessment needed

The students also shared a few concerns related to accessibility. For example, e-assessment with e-authentication will require technical assistance and more alternatives for SEND as described below.

- "Low fine motor students had problems with keystroke dynamics" (OUUK).
- "Students with dyslexia who stammer were not comfortable with voice recognition" (SU).

Interviewees also commented about security and privacy. TeSLA enables flexibility of e-assessment "*A person can shift comfortably from the human-managed exams to the system-managed exams*" (AU). They mentioned that "*most of the students did not point privacy issues as they participated in the pilot on a voluntary basis*" (UOC). However, some educators indicated that "*There were some students who did not want to share their information*" (AU). They also shared that "*Students are*

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nowadays more aware of the privacy and security issues than earlier, and that they can and will question these matters" (JYU).

- "Our students found positive to be informed about Data Protection including consent form, but some of them presented various questions, such as: what data is sent when TeSLA is active? How is the data sent? What protocol is used? Is the data transmission secure? Will they be forced to use this regardless of their data privacy?" (OUUK).

Their comments related to fraud, prevention and trust, revealed their views in terms of cheating prevention: They consider that "*e-authentication will increase the trustworthiness of e-learning however fraud would still be possible*" (SU), and fair assessment and accreditation: "*teachers considered that the system will make students feel more secure for those students that do not cheat*" (UOC). Interviewees perceived TeSLA as "*reliable system that fits to contemporary living and recent trends in higher education.*" (SU), which "*will increase the confidence of the institution*" (TUS). Teachers see that "*there is a lot of possibilities with the use of TeSLA, especially if it provides reliable results*" (OUNL). Interviewees also suggested to use different systems for plagiarism detection; "*Combining the use of TeSLAPL with other systems such as Turnitinand CopyCatchwill help course teams identify external and intrinsic plagiarism*" *(OUUK).*

In terms of pedagogical issues, interviewees mentioned that e-authentication requires some changes about existent course design, for example, "*more open-ended questions OUNL*" Interviewees considered that TeSLA system will increase the opportunities of "*new kinds of assessments*" (JYU). For that variety and regularity will be necessary, that means, "*variety of types of assessment*" (AU) and "regular assessment *that creates extra chances to demonstrate what has been learned and done during the course*" *(OUNL).*

Discussion

The teaching staff used diverse pedagogical approaches with a range of scenarios and types of e-assessment, which matched the authentication tools chosen and plagiarism detection (JISC, 2010; Kakkonen & Mozgovoy, 2008; Wulff, 2008). All instruments opened up new types of both formative and summative assessments (Trumbull & Lash, 2013; Whitelock, 2011; Okada *et al.*, 2018). Nevertheless, the response type and response format constituted the basis for the selection of instruments. Depending on the response type of e-assessment activity, some instruments were more suitable than others. The revised Bloom's taxonomy (Bloom *et al.*, 1956) has assisted with the description and communication of adapted pedagogical activities for e-assessment with e-authentication.

Partners applied a student-centred pedagogical approach (Baneres, Baró, & Guerrero-Roldán, 2016; ESG, 2015) for the e-assessment activities using TeSLA instruments. The assessments were designed to allow the students to reveal their skills and understanding of the different knowledge domains to the best of their abilities. The teachers also wanted to increase the students' trust in the various authentication tools and the system as a whole. This is because the consent forms complied with EU regulations (EC, 2012; EMHE, 2012). These forms were communicated as simply as possible so that students could understand that their personal data was protected according to GDPR (Albrecht, 2016). Any information from their TeSLA usage would be applied within their own University's Policy & Procedures if cheating was detected.

Pilot coordinators play an important role to communicate needs and technical issues to the technology developers and keep course teams and students—including special educational needs students—well informed and supported on security and privacy as well as on fraud detection (QAA,

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2016), prevention and trust (Mellar, Peytcheva-Forsyth, Kocdar, Karadeniz, & Yovkova, 2018; Okada *et al.*, 2018; Park, 2004).

Participants described a positive acceptance of TeSLA instruments and consider that it will increase students' awareness of cheating and plagiarism and the trustworthiness of e-assessment, but it will not eliminate the possibility of fraud. They also provided some suggestions to support the trust in the system and instruments including ways to face problems in using these forms of technological assistance. Seven recommendations were formulated to support teaching staff with the TeSLA system:

Technical needs

1. **Technical FAQ** that provides information about the system will be useful for teaching staff to avoid or deal with problems faced by them or their students.
2. Prompt **audit report** about the results of each instrument with guidelines for the university staff will be essential for them to check and interpret results and ensure the quality of the e-assessment.

Organisational issues

3. **Data security and privacy awareness** for teaching staff and students will be useful through more information about the e-authentication and authorship verification instruments to promote trust in the system.
4. Universities must develop and share **e-authentication and authorship verification policies** for verifying and dealing with fraud. This should include legal and ethical recommendations to deal with problems and measures to prevent academic malpractices and for quality assurance.
5. Local guidelines such as a **manual about the instruments** with instructions should include information on data protection and privacy; and fraud detection and prevention.

Pedagogical aspects

6. Pedagogical teams must discuss and share **best practices of e-assessment** that can be combined with TeSLA instruments.
7. Universities should offer **course team support** for academic staff to plan useful activities and e-assessment tasks with TeSLA system.

Final remarks

The e-assessment activities were designed to fit the TeSLA instruments, but like any pilot study technical difficulties arose. The RRI approach (EC, 2017; Von Schomberg, 2011) enabled the interaction between technology innovators with teaching staff and their views about their students' opinions to better align the TeSLA system development with the priorities and concerns of the end-users (Okada *et al.*, 2018). Issues such as the improvement of the instruments' reliability and its accuracy must be dealt with for the next round of testing. Additionally, views and concerns of teaching staff about the prompt reporting of outcomes and the instruments prevention audio and video attack (VPAD and FPAD) indicate the need for more assistance in determining student identity. This is addressed in the final version of TeSLA. Furthermore, a study with other plagiarism detection systems, such as Turnitin Urkund, SafeAssign, CopyCatch and TeSLA was implemented (Edwards *et al.*, 2018). This study revealed that these systems can be used by the

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same institution for complimentary checks. Different ways of checking plagiarism will be helpful for teaching staff to ensure trust in e-assessment.

Good academic practice in (online) teaching should recognise academic malpractice such as external and intrinsic plagiarism (Appelgren Heyman *et al.*, 2012; Ferrell, 2014; Potthast, Eiselt, Barrón Cedeño, Stein, & Rosso, 2011) including impersonation and presentation attack (Nikisins, Mohammadi, Anjos, & Marcel, 2018), which has become more common. All these forms of cheating and plagiarism should be addressed by academic staff (Ivanova *et al.*, 2016; Kambourakis & Damopoulos 2013; Pell, 2018) with pedagogical strategies for e-assessment supported by the effective use of technologies, such as the TesLA system.

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Statements on open data, ethics and conflict of interest
According to the consent forms presented to and agreed by participants, data can't be made available to third parties.

Ethical approvals were gained from the hosting institution.

No conflict of interest has been declared.

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