# Open Research Online

## An Evaluation Methodology Applied to Trust-Based Adapted Systems for e-Assessment: Connecting Responsible Research and Innovation with a Human-Centred Design Approach

## Book Section

For guidance on citations see FAQs.

# An Evaluation methodology applied to trust-based adapted systems for e-assessment: connecting Responsible Research and Innovation with a Human-centred design approach

Okada, Alexandra[1] (correspondent author) and Whitelock, Denise[2]

[1] The Open University, UK, ale.okada@open.ac.uk

[2] The Open University, UK, denise.whitelock@open.ac.uk

**Abstract.** This chapter describes a novel evaluation methodology designed, deployed and refined during the development of the EU-funded TeSLA system which was produced to check student authentication and authorship. This methodology was underpinned by a Responsible Research and Innovation approach combined with human-centred design. Participants were 4,058 students, which included 330 with special needs, together with 54 teaching staff and 21 institutional members from seven universities who completed consultation, focus groups, questionnaires and interviews. The findings suggest that the evaluation methodology was able to identify a broadly positive acceptance of and trust in e-authentication for online assessments by both women and men, with neither group finding the e-authentication tools to be either particularly onerous or stressful. The methodology facilitated the development of a framework with five features related to "trust": 1. The system will not fail, 2. be compromised, 3. data will be kept safely and privately, 4. the system will not affect students' performance and 5. the system will ensure fairness.

**Keywords:** Evaluation methodology, trust-based adapted systems, Responsible Research and Innovation, Human-centred design approach, Academic Integrity

## List of acronyms:

RRI      Responsible Research and Innovation
HCD      Human-centred design
NGO      Non-Governmental Organisation
VLE      Virtual Learning Environment
LTI      Learning Tools Interoperability
CIC      Computer Integrated Communication
SEND      Special Educational Needs and Disability
API      Application Programming Interface

# 1. Introduction

Responsible Research and Innovation (RRI) is a recent approach, which was coined by the European Commission at the beginning of this decade. It became a vital approach for funded research projects, particularly by the European Commission, such as the programme Horizon (2014 to 2020).

RRI has been applied to various fields with the aim to align scientific-technological advances with societal needs and expectations (Von Schomberg, 2011; Stilgoe et. al. 2013). This constructive alignment occurs through the interaction of all distinctive societal representatives during the all phases of the innovation process: designing, planning, implementation, testing and evaluation. The purpose of RRI is to promote greater involvement of societal members in the process of research and innovation from the beginning to increase knowledge, understanding and better decision-making about both societal needs and scientific innovations (EC, 2012; 2017).

There are various similarities between RRI and the human-centred design approaches for developing and evaluating technological innovations. This chapter presents the evaluation methodology used during the European-funded TeSLA system, which was funded as part of the European Horizon2020 programme: innovation-action for large scale impact. The TeSLA system was designed to check student authentication and authorship through a combination of biometric, textual analysis and security instruments.

- **Biometric instruments** refer to facial recognition for analysing the face and facial expressions, voice recognition for analysing audio structures and keystroke dynamics for analysing how the user uses the keyboard).
- **Textual analysis instruments** refer to plagiarism detection for using text matching to detect similarities between documents and forensic analysis for verifying the authorship of written documents.
- **Security instruments** refer to digital signature for authenticating and timestamp for identifying when an event is recorded by the computer.

This evaluation methodology was developed through an interactive process with all members of TeSLA project. It was implemented in three phases with all stakeholders including 7 Universities located in 6 countries.

This chapter is organised into five sections after the Introduction. In section 2, we present the principles of RRI and the correlations with the human-centred technology approaches for software development which underpinned this work and our research questions. Section 3 illustrates the implementation of this evaluation during 3 pilot studies. Section 4 described the findings which were integrated from all pilots with recommendations for stakeholders. Section 5 discusses the findings from the implementation of the TeSLA system in 7 Institutions and its limitations. Finally, section 6 includes the final remarks and suggestions for future work.

# 2. Background

The evaluation model implemented for the European TeSLA system for e-authentication and authorship verification was developed in 3 stages and involved five

groups of stakeholders: students, teaching staff, pilot coordinators, technical teams, and institutional leaders. The model was conceived, developed and implemented through the continual interaction of technological innovators and end-users. This section presents the Responsible Research and Innovation principles, components and stakeholders who underpinned our work.

The Responsible Research and Innovation (RRI) approach is grounded on previous work developed by the European Commission about Ethics in Science Technology (Owen et al., 2012). RRI approach was disseminated at the end of FP7 programme as a vital approach to highlight the importance of promoting scientific technological innovations with and for society and foster scientific advances to ensure security, prosperity and sustainability (Okada & Rodrigues, 2018).

Various scholars who have been working with technological and scientific innovation, policies and science with for society have been presenting RRI through various definitions, principles and examples. Von Schonberg (2011)'s definition is one of the most influential description of RRI:

> *"Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society)."*

Our evaluation approach was conceived to provide transparent procedures and interactive methods to engage Institutions and the TeSLA consortium members to responsibly reflect on the ethical acceptability, sustainability and societal desirability of e-authentication with authorship verification. RRI approach was useful to properly embed the innovative system to ensure scientific and technological advances in terms of technology-enhanced assessment (Stödberg, 2012) for academic integrity (Simon et al, 2013).

There are a set of six components (EC, 2012; Stahl, 2013; Stilgoe et al. 2013; Owen et.al., 2012) that must be taken into account to develop RRI practices:

- **Governance** refers to a set of principles, procedures, instruments and recommendations to foster responsibility and accountability among all actors to ensure acceptable and desirable outputs from scientific innovations. Our evaluation process engaged TeSLA partners and Institutions to reflect and establish the governance collaboratively.
- **Scientific education** aims to equip citizens with knowledge, skills and attitudes for all societal members to participate in R&I debates with evidence-based thinking. Our evaluation instruments included a set of educative artifacts such as TeSLA videoclips, Informed Consent, FAQ and guidelines prepared by the Course and Technical Teams to support students with various issues such as: data privacy and security (including ethics), technical problems, special educational needs requirements (accessibility), e-authentication and authorship verification steps, system interface (usability) and information about cheating and plagiarism.

- **Ethics** supports research integrity through the awareness and prevention of research practices that are unacceptable. It considers principles and procedures to minimise the risks of scientific and technological developments. In TeSLA, our evaluation approach engaged all pilot partners and project leaders to discuss ethical issues, including the General Data Protection Regulation (GDPR), safe procedures for consent forms and guidelines for evaluation data management using common and protected templates with anonymised data. Our questionnaire and focus group guides were designed to include ethical reflection.
- **Open access** contributes to good research practices and knowledge sharing, as well as allowing others to adopt or adapt their approaches and encourage innovation. Our evaluation model led to a set of publications with open access (Okada Whitelock et. al. 2019; Okada, Noguera et. al. 2019) and also academic findings were translated to open educational resources, such as articles published in the OpenLearn platform (Okada, 2018) to support formal and informal education.
- **Gender** equality is key to ensuring diversity of participants, providing gender balance with equal opportunities for all involved in research projects. Our evaluation studies considered gender issues, whose findings were also published and used to inform all stakeholders.
- **Public participation** promotes inclusion, research activities and innovation, in which they need to inform and generate reflection for a better understanding of social, cultural and environmental contexts, thus engaging organizations and society. Our evaluation outputs were presented in public events for large audiences, including events, conferences and social media. We also reached more than 1,000 open learners who contributed to our evaluation from different countries.

There are eight principles which guide RRI practices (EC, 2017; RRI-TOOL, 2016) described as follows:
- **Diversity and inclusion:** these principles aim to engage a wide range of participants (innovators with society) at early stage in RRI practice with interactive methods such as deliberation, consultation and collaborative decision-making. This promotes wide access to knowledge and sources of expertise. In TeSLA, our evaluation methods engaged all distinctive groups of stakeholders in all stages of TeSLA project.
- **Anticipation and reflection**: aim to better understand how RRI shapes the future, which means we need to identify impacts, consequences, risks and benefits. In TeSLA, our evaluation procedures were designed to gather valuable insights for increasing our pre-knowledge for better evidence-based decisions.
- **Openness and transparency:** aim to communicate methods, findings, and implications in a meaningful and effective way for enabling societal dialogue. The visibility and understanding of Research and Innovation through an open and transparent way helped TeSLA to reach very large communities in a considerable number of countries.
- **Responsiveness and adaptation**: aim to be able to respond to changes and modify modes of thought and behaviour in response to new circumstances, knowledge, and perspectives. This aligns the actions with the stakeholders' and

public' needs. In TeSLA, our evaluation outcomes provided a set of recommendations to respond and adapt to issues that emerged for all stakeholders, during the three phases of the project.

The RRI projects completed to date highlight five groups of society who should interact in all phases of any development and evaluation of new work (EC, 2017). These are:

1. **Research community**: refer to academic researchers, innovative scientists, research managers, public affairs and communication officers. In the TeSLA project, this included all professionals and 'pilot coordinators' involved in the research studies, data collection and data analysis.

2. **Education community:** refer to teachers, teacher trainers, pedagogical coordinators, 'technical teams', course developers and students. In the TeSLA project, this involved all educational members, such as: teaching staff, course teams, assessors, learning designers, lecturers and instructors.

3. **Business industry and companies:** are large, medium and micro-enterprise, professional entrepreneurs' groups, 'technology developers', including transnational organizations and institutions. In the TeSLA project, this group included technology providers and exploitation companies interested in TeSLA system as well as technology developers of the TeSLA instruments: facial recognition, voice recognition, keystroke dynamics, forensic analysis and plagiarism detection system.

4. **Policy makers and policy influencers:** they range from influential policy makers to policymakers, directors of research centres and representatives of scientific societies, whether at European, national or local level. In the TeSLA project, this group involved all those who defined how research and innovation should be carried out in their own area of influence and also 'institutional leaders'.

5. **Civil and Society organization**: are individuals to organizations, including NGOs (Non-Governmental Organisations), communities, media professionals, representatives of civil society. In TeSLA, this group engaged open learners, non-formal learning providers (e.g. OpenLearn community) who contributed to discussions and reflected about how the TeSLA system and instruments meet the needs of society for formal and informal education.

## 2.1 Correlations between RRI and human-centred design approaches

Human-centred design methods (Seffah et al., 2005) are recognised as a significant approach for technology development and system evaluation through continual interaction with end-users to ensure that the innovation will address their needs and expectations. The Human-centred design approach considers human perspectives in all steps of the technology innovation (Leveson, 2000). The interactive process with end-users enables software engineers to examine the requirements more effectively with the end-users. The human interaction is initiated at early stage by discussing the problem within context, brainstorming, conceptualising, designing, developing and evaluating the first technology innovation model. These iterative and cyclic procedures enable innovators to improve the technology system and identify the relevant factors about costumers' acceptance or adoption and product's scalability.

However, some barriers highlighted by the literature might potentially impact on the process of evaluation such as the lack of users' interaction, usage and feedback (Rubin & Chisnell, 2008). These barriers include the users' difficulties and concerns. There are various factors that might affect the user experience and consequently the evaluation process, for example, technical problems, usability and accessibility issues, data privacy and security, lack of digital skills, training and support. One of the difficulties to implement human-centred approaches is there is a high level of novelty, uncertainty and potential risks which might impact on the user experience and may cause dropout. To explore this challenge, the evaluation model developed and implemented during TeSLA project was refined based Human-centred design approach combined to RRI as described by Table 1. All these approaches, which are iterative in nature enabled the gathering of data together with recommendations and lessons learned related to the challenges (novelty, uncertainty and potential risk) to build expertise throughout the 3 phases of the empirical studies. The Human-centred Design model described through 3 stages (*prototype, deployment, exploitation*) focuses on user requirements to better align with the technology development (Salah et al, 2014), whereas RRI (presented also with 3 phases (*planning, development and sustainability*) focuses on the societal actors (all stakeholders)' needs and expectations to align more closely to the innovation process. Our model used in TeSLA combines requirements, needs, expectations and trust experience to dove tail with the innovative trust-based system through 3 pilot studies (*small, medium and large*).

Table 1. Evaluation model for the TeSLA project refined with respect to RRI and Human-centred design

| Human-centred design | Responsible Research &Innovation | Evaluation model for Trust-based e-assessment system |
|---|---|---|
| **Prototype:**<br>1. Initial Planning<br>2. Initial Requirement<br>3. Initial Design<br>4. Minimum implementation<br>5. Small pilot with users<br>6. Component Tested | **Planning:**<br>1. RRI Introductory Plan<br>2. Initial participants interaction<br>3. Needs identified<br>4. Next steps planned<br>5. Innovation discussed<br>6. Initial Feedback collected | **Small Pilot Study:**<br>1. Small pilot evaluation plan<br>2. Consent Form<br>3. Stakeholders Consultation<br>4. Questionnaires design<br>5. Initial Trust data collection<br>6. Requirements and recommendations |
| **Deployment:**<br>1. Detailed Planning<br>2. Requirement analysis<br>3. Integrated Design<br>4. Major Development<br>5. Integrated System Test<br>6. Medium pilot with users | **Development:**<br>1. RRI exploitation Plan<br>2. Multi-Stakeholders engaged<br>3. Expectations discussed<br>4. Implementation<br>5. Innovation improved<br>6. Feedback collected | **Medium Pilot study:**<br>1. Medium pilot evaluation plan<br>2. Consent Form<br>3. Focus groups<br>4. Pre- Questionnaire<br>5. Instruments-Trust feedback<br>6. Post-questionnaires |
| **Exploitation:**<br>1. Plan for scalability | **Sustainability:** | **Large Pilot Study:** |

| 2. Requirement for new users<br>3. Expanded Design<br>4. Development/Deployment<br>5. Large-scale testing<br>6. Large scale-evaluation | 1. RRI sustainable Plan<br>2. Public Engagement<br>3. Next priorities identified<br>4. Final steps planned<br>5. Innovation consolidated<br>6. Final Feedback collected | 1. Large pilot evaluation Plan<br>2. Consent Form<br>3. Focus groups and Dropout analyse<br>4. Pre- and Post-questionnaire<br>5. Trust System feedback and reports<br>6. Stakeholder Interviews |
|---|---|---|

## 3. Implementation of Pilots

Three pilots were conducted to obtain data about the usage of TeSLA system with information feedback and recommendations to refine the instruments and protocols.

1. **Small Educational Pilots**: In this first stage, seven institutions engaged together 500 learners during the first year of the project. In this phase, the TeSLA system was under development, therefore no technology to be tested, but the defined protocols and data flows between the project members and stakeholders (learners, teachers, auditory, ...) were implemented and evaluated. The learning and assessment activities to be used with TeSLA system were tested and evaluated. A first critical risks guideline was also defined by the project team.
2. **Medium Test-bed Pilots**: This second phase was conducted during the second year of the project with the TeSLA system with the five instruments. Approximately 3,500 learners used TeSLA instruments.
3. **Large Scale Pilots**: This final phase was conducted during the third year of the project. Two rounds were performed during this phase, involving a total of more than 17,000 learners. The goals of this phase were: 1) To test the TeSLA system's integration and scalability. 2) To test the refinement of the TeSLA e-assessment Model in a large-scale scenario. 3) To test the reliability of authentication and authorship mechanisms.

In each pilot a set of 10 steps (see Fig. 1) were implemented to support the evaluation process.
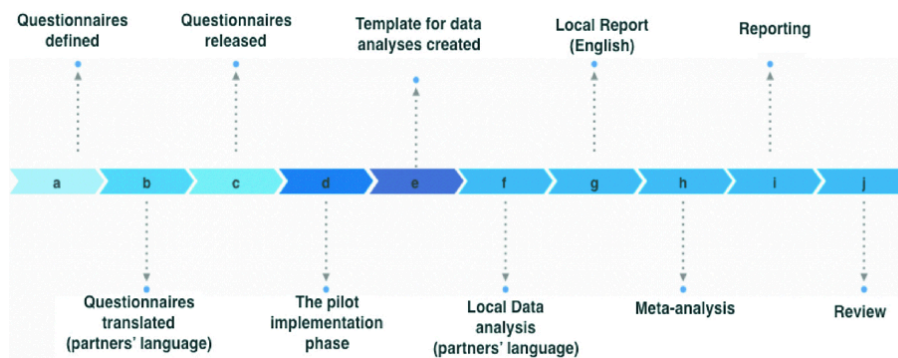


Fig. 1. Steps used to implement our methodological approach

The pre-pilot and post-pilot questionnaires for students and teaching staff were implemented by means of an online template set-up using the Bristol Online Survey system (https://www.onlinesurveys.ac.uk/). This survey system has now been transferred to JISC. All partners used the same survey system with an identical set of questions. Each of the seven partners was responsible for translating questionnaires into their local language. In addition, the three questionnaires for the pilot coordinator, the institutional and technical leaders were constructed and ran in English.

Each partner implemented their data collection and statistical analysis with respect to their local context. The partners' data analyses were then integrated and interpreted before the final steps, which included writing the evaluation report with recommendations and receiving peer-review feedback.

## 3.1 Evaluation questions

Table 2 presents the nine thematic categories grouped the nine overarching thematic questions for the TeSLA pilots, through stakeholders' deliberation and consultation events.

Table 2. Overarching principle questions used in Pilot-3

| THEMATIC CATEGORIES | KEY THEMATIC QUESTIONS |
|---|---|
| 1. STUDENT PERSPECTIVES | What are student´s perceptions about e-authentication systems and TeSLA tools? |
| 2. STAFF PERSPECTIVES | What are educators´ views on TeSLA interface and students´ experience? |
| 3. TECHNOLOGY DEVELOPMENT | What are the technical team´ views about the data & system integration? |
| 4. EFFECTIVENESS OF THE AUTHENTICATION AND AUTHORSHIP | How effective is TeSLA system in authentication and authorship verification? |
| 5. ASSESSMENT DESIGN AND PEDAGOGY | How engaged are teachers and managers in assessment design, teaching, training and support with TeSLA system? |
| 6. AWARD BODIES AND POLICY MAKERS | Does TeSLA contribute to and support national education policy and social aspirations? |
| 7. STAFF, RESOURCE AND FINANCIAL COSTS | What was the technological readiness of staff? |
| 8. METHODOLOGY | What are the issues related to data collection and analysis, students´ consent, SEND participation? |
| 9. TRUST | Do users feel informed, comfortable and confident with the TeSLA system? |

## 3.2 Participants

There were seven Higher Education organisations in total who participated in the three pilots: two online learning institutions (Universities 4 and 7) and five universities with blended learning courses (Universities 1, 2, 3, 5 and 6). The number of students who completed the evaluation questionnaires were 336 during pilot1 - 2016, 1,085 during pilot2 in 2017 and 4,428 during pilot 3 in 2018. This chapter focuses on data about pilot3 final phase, which refers to the final evaluation of the TeSLA system. The participants included a large group from the universities: 67 teaching staff, 7 pilot coordinators (research role), 7 technical teams (IT department), and 7 institutional leaders (director role) who contributed with their views[1][DB1].

In terms of students' participation in the pilots, there were a total of 11,102 who used TeSLA system in pilot 3 (final stage). The total of students who replied the pre-questionnaire was 3,528 and the post-questionnaire was 2,222. The total of teaching staff who also completed pre- and post- questionnaires was 67. There were 7 technical teams' coordinators, 7 pilot' coordinators who were interviewed and 7 institutional leaders (Table 3). The seven institutional leaders from the 7 institutions who replied a questionnaire were:1. Dean, 2. Director of Distance Education Centre, 3. Vice manager of the Learning Technologies and R&D Department, 4. Manager educational logistics, 5. Associate Director Quality Enhancement Prof Technology Enhanced Assessment and Learning, 6. Director, 7. IPR manager.

**Table 3. Summary of Students data - Pilot 3 from questionnaires**

| Universities | 1 | 2 | 3 | 4 | 5 | 6 | 7 | TOTAL |
|---|---|---|---|---|---|---|---|---|
| Target – (expected number of students) | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 1500 | 10500 |
| Total of students (unique participants) | 2,325 | 1,844 | 417 | 1,617 | 1,457 | 1,574 | 1,868 | 11,102 |
| Students who used Facial recognition | 2684 | 100 | 9 | 25 | 644 | 1163 | 1116 | 5741 |
| Students who used Voice recognition | 247 | 54 | 0 | 0 | 117 | 370 | 235 | 1023 |
| Students who used KeyStroke Dynamics | 247 | 250 | 29 | 0 | 46 | 407 | 915 | 1894 |
| Students who used Forensic Analysis | 53 | 1661 | 229 | 126 | 189 | 150 | 686 | 3094 |
| Students who used Plagiarism Detection | 48 | 1586 | 365 | 1541 | 814 | 321 | 1674 | 6349 |
| Students who replied pre-questionnaire | 240 | 167 | 84 | 853 | 232 | 783 | 1169 | 3528 |

---

[1] The role of the different actors within the project can be reviewed in Chapter 8, Section 4.2

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Students who replied both the pre- and post-pilot questionnaires | 171 | 115 | 57 | 574 | 226 | 452 | 627 | 2,222 |
| Students Dropout rate | 29% | 31% | 32% | 33% | 3% | 42% | 46% | 29% |
| Teachers who replied both the pre- and post-pilot questionnaires | 8 | 8 | 3 | 4 | 4 | 6 | 34 | 67 |
| Pilot Coordinators Interviews | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |
| Technical teams Interviews | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |
| Institutional Leaders Interviews | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 7 |

### 3.3 Limitations

During the three pilot studies there were a few limitations/caveats. Some institutions did not have access to system instruments results of e-authentication and authorship verification. Two institutions used the TeSLA system in a separate VLE (Virtual Learning Environment) universities 3 and 4. In addition, all students who used TeSLA and signed the informed consent form were volunteers and two universities engaged a low number of participants (universities 2 and 3).

## 4. Findings

Our results were grouped based on the overarching principle questions presented in Table 2.

### 4.1. STUDENT PERSPECTIVES: What are students' perceptions about e-authentication systems and TeSLA tools?

In terms of the benefits of e-assessment with e-authentication most students (more than 70% of participants from each institution) selected various advantages (Fig.2). The most popular reasons chosen for using a system such as TeSLA were to prove that their work is authentic, to improve the rigour of assessment, to ensure trust and prevent cheating.
Only a few of them mentioned that there was no advantage. Students from Universities 1, 4 and 7 provided other examples about the advantages of e-authentication with e-assessment, such as:
- University 1: Reliable and fair evaluation, location and time independence.
- University 4: Less stressful and more adapted to my mental problems, to not have to travel to an examination centre and avoid all the associated logistics, (transport, time off, childcare, school pick-up, etc). Realistically, most real-life applications of what we have learned would allow for the source material to be available for consultation.

- University 7: To Avoid face-to-face exam, to help SEND students (reduced mobility), and less stressful.

There were also students who pointed out disadvantages from all institutions (Fig.3). More than 20% from each institution mentioned that e-authentication in e-assessment can be intrusive. More than 55% of students from universities 1, 3 and 5 mentioned that have to share personal data and e-authentication can involve more work than traditional assessments. The other reasons were:  reliability about outcomes, technical issues, more time and challenging. Qualitative data from students from three institutions also indicate other difficulties:

- University 2: Internet connection problems, blackouts during the process, or lack of technical skills. In online assessment, personality features and communication do not affect interpretation and evaluation. It is impossible to or difficult to ask clarifying questions.
- University 3: Reducing interaction with other people too much reliance on technology; too many factors that can go wrong; the system might not work properly or might not adapt to changing model, not suitable for type of assignments/software to be used, e-authenticated exams not clear or not applicable.
- University 4: There may be always faults that make system difficult to be used, for example, a new computer with a different kind of a keyboard, new glasses, flu etc. The system might not recognise the person with a different appearance. The system may be unstable and work insecurely, e.g. logging out suddenly and losing all the work done.
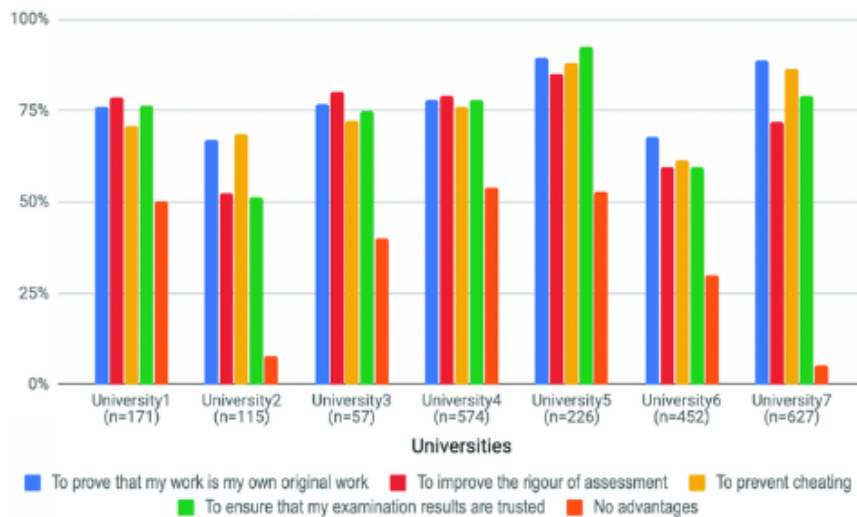


Fig. 2. Students' opinions about the main advantages of e-authentication in e-assessment - data from post-questionnaire
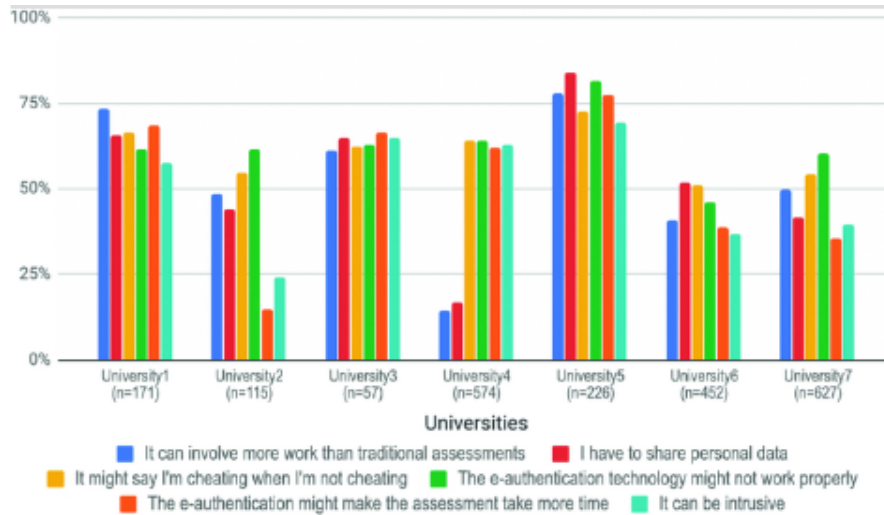
### 4.2. STAFF PERSPECTIVES - What are the educators´ views on TeSLA system and students´ experience?

Most teaching staff found TeSLA an user-friendly and relevant system. They indicated three main advantages for using an e-authentication based e-assessment system: to avoid having to take an examination under formal examination conditions, to have assessments better adapted to students needs and to allow anytime anywhere assessments. However, they also highlighted three key issues: all students must share their personal data, the system must work properly, and it might take more time for students to complete e-assessment. In addition, more than 30% of teachers from four institutions (universities 1, 4, 5, 6 and 7) listed some concerns about TeSLA system: it can involve more work than traditional assessments and it might say a student is cheating when they are not.

Pilot leaders were asked what their institution expect the TeSLA system to do to assist them with e-assessment. They listed four key factors:

- *A system which triggers warnings about cheating and dishonesty behaviours. Then, the teachers only have to check these potential cases.*
- *Clear and accurate feedback for student authorship and authentication in the assessment activities.*
- *Additional information to assist teacher in determining authorship.*
- *Secure platform and reliable results.*

Pilot leaders were also asked whether they would recommend TeSLA to another colleague. Five pilot leaders said yes because:

- *The opportunities it gives for e-assessment.*

- *It will enable secure e-assessment and provide opportunities for using different assessment activities.*
- *With some restrictions. So far, we have little insights that shows that TeSLA works.*
- *It may contribute to increase the trust by reducing cheating and dishonesty behaviours.*
- *It has a great potential to make e-assessment more secure for teachers, and for students to become more responsible in the assessment process.*

### 4.3. TECHNOLOGY DEVELOPMENT - What are the technical team´ views about the data & system integration?

The directors of the technical teams of each institution who were responsible for the TeSLA system integration were also interviewed. Four institutions (Universities 2, 3, 5 and 6) integrated TeSLA system in their institution VLE. Two institutions integrated it in an external system linked to their Institution VLE (Universities 1 and 4). Another institution (University 7) used both approaches.

They were asked whether they faced issues with the TeSLA system integration with the VLE and student records system. Only one technical team reported no problems (University 7). The other six technical teams described various issues, such as:

- *In transversal assessment tools, like a classroom forum, there is no way in TeSLA to define time periods to restrict the audit data to the content generated for each learning activity.*
- *There were some issues revealed during the initial tests which were solved quickly with help of the TeSLA technical team. After the start of the pilot Keystroke Dynamics enrolment has stopped working and it was cancelled in all the planned activities. The problem was resolved in some weeks ago.*
- *We found that integration would be impossible, given project and university constraints, we focused on a standalone system. We developed custom student-data import functionality for Moodle.*
- *VLE and student records system are 2 different systems. We only integrated TeSLA with our VLE. There were many issues to solve, first of all because proper documentation was missing.*
- *Some installation issues. Some documentation problems.*
- *We did not get answers for some problems that we reported.*

The technical teams also mentioned problems faced by students with service disruption, delays or disconnection:

- **Browser:** *Sometimes we got issues with some browsers.*
- **Various implementation issues**: *The system is working but with lot of changes and small issues solved during the implementation.*
- **Enrolment:** *Yes, [we faced problems] especially when enrolments were performed in face-to-face mode. The system was not stable and could not send all the information simultaneously. The strength of the internet connection was also very important (Wi-fi or mobile).*
- **Technical skills:** *Students were invited (not mandatory). Some of those who responded struggled.*

- **Upgrades**: *Some issues related to infrastructure upgrades, performed during the project.*
- **Instability and delays:** *The TeSLA system was not stable enough in the beginning of pilots, so there were delays on the courses. Some course activities had to be skipped.*

Five institutions reported significant extra workload for the institutions' technical teams due to problems faced by students with service disruption, disconnection and instability of the system. However, five institutions have confirmed their intention and capacity to continue using the TeSLA system after the project's completion.

### 4.4. EFFECTIVENESS OF THE AUTHENTICATION AND AUTHORSHIP - How effective is TeSLA system in authentication and authorship verification Instruments?

The overall students' experience with the TeSLA instruments was positive for more than 50% of the students from all partner universities. More than 70% participants from all universities found that the instruments were easy to use. More than 60% were comfortable with the system and would be willing to use it in future online assessments. Three main factors contributed for participants to feel confident with the instruments: very clear and detailed instructions; familiarity with the system and tutorials with guidelines. Users provided positive feedback from all instruments:

- **Facial recognition** (Fig. 4) was used by students from most universities apart from University 3. Half of the participants (50%) considered it not intrusive, they were comfortable and would be willing to use it again, apart from university 6 (only 25% found it did not take too much time and were willing to use it again).
- **Voice recognition** (Fig. 5) was used by students from five universities (universities 1, 2, 5, 6 and 7). Approximately half of the participants (50%-60%) were comfortable to use this instrument, and willing to use it again apart from University 1 (20%) and University 5 (27%).
- **Keystroke dynamics** (Fig. 6) was used by students from six institutions (except university 4). Most students were comfortable to use this instrument, and willing to use it again particularly from universities 3 and 7 (75%).
- Students from all institutions used **Forensic Analysis** (Fig. 7) and **Plagiarism Detection** (Fig. 8). Their opinion across institutions were very similar (apart from University 6). Many students were comfortable (more than 70%) and half of them willing to use it again (particularly Universities 3 and 7).

Pilot Coordinators also presented their views about the effectiveness of the *TeSLA* system for authentication (successful and failed attempts, inauthentic and inappropriate uses; disruption and invasion). Pilot Coordinators presented some benefits of using e-authentication such as new types of assessments and the opportunities for increasing trust by reducing cheating and academic malpractice. Five institutions would recommend TeSLA to another colleague. Two institutions who reported that they were not sure highlighted that the technological implementation was difficult.

As the results of e-authentication were not available during pilot 3, all Pilot Coordinators reported that they were not sure whether the TeSLA instruments assisted the Institution in checking e-authentication.

The seven Institutional Pilot Coordinators were asked if the suite of TeSLA instruments assisted their Institution with checking e-authentication and whether teaching staff had been able to review the outcomes promptly. There were two institutions who were not sure and five who mentioned that they did not. Pilot coordinators from universities 1, 3 and 4 replied that they could not answer this question, because teaching staff have not seen the outcomes. Universities 5 and 6 believe that TeSLA assisted in e-authentication, but they were also unable to confirm it. Universities 2 and 7 also mentioned that they are not sure "*Results for some instruments just begin to be available*", but they "*have not analysed the feedback yet*" and "*did not know how well or properly TeSLA instruments are working*".

University 7 reported that *"the results of Facial Recognition were useful. Keystroke dynamics results were difficult to interpret and additional explanations from the technical colleagues have been required. Regarding the other instruments, and considering the information we currently have, our impression is Plagiarism will be easily understandable, and Voice Recognition may suffer similar problems of interpretation to those described for Keystroke Dynamics. The results for Forensic Analysis are unknown (the technical team is working on that)."*
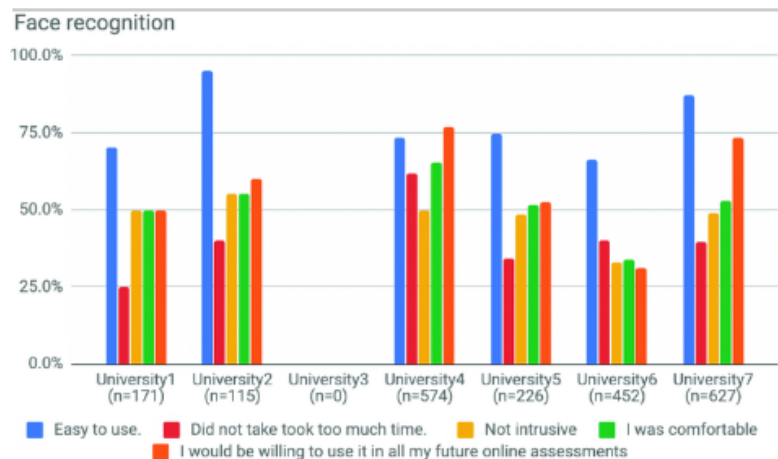


Fig. 4. Students 'opinions about facial recognition instrument - data from post-questionnaire
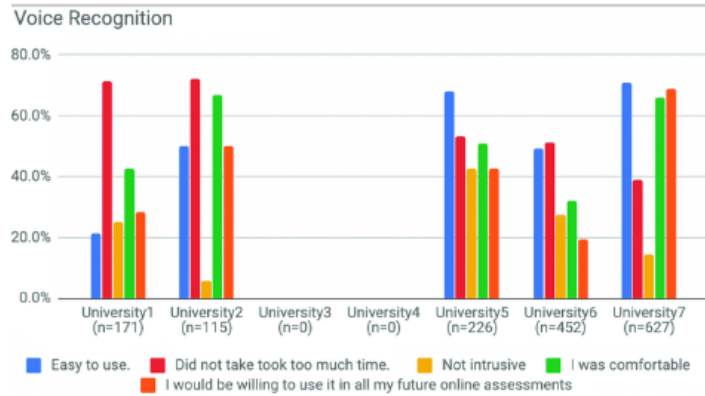
**Fig. 5. Students 'opinions about voice recognition instrument - data from post-questionnaire**
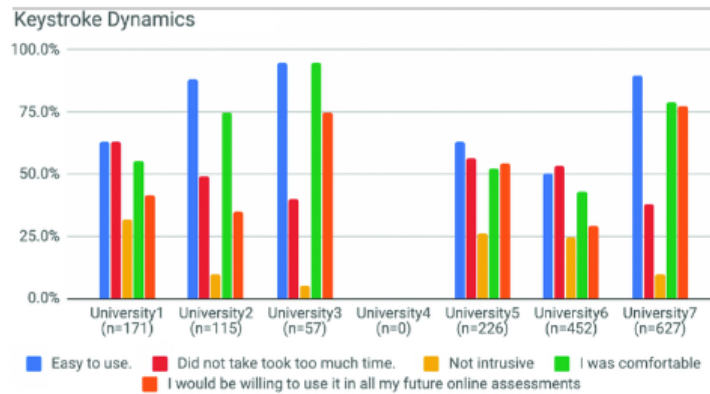


**Fig. 6. Students 'opinions about Keystroke dynamics instrument - data from post-questionnaire**
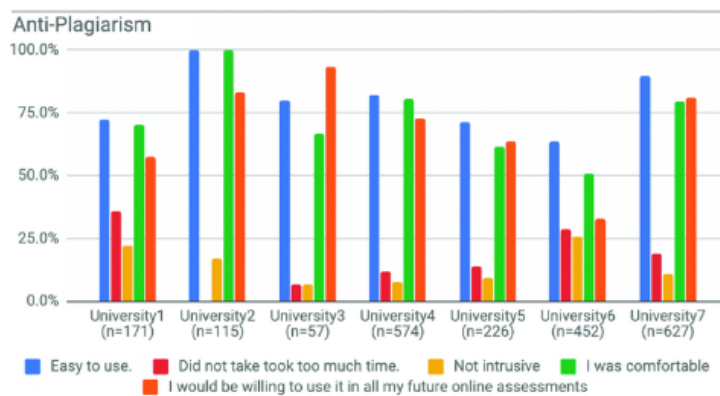


**Fig. 7. Students 'opinions about plagiarism detection instrument - data from post-questionnaire**
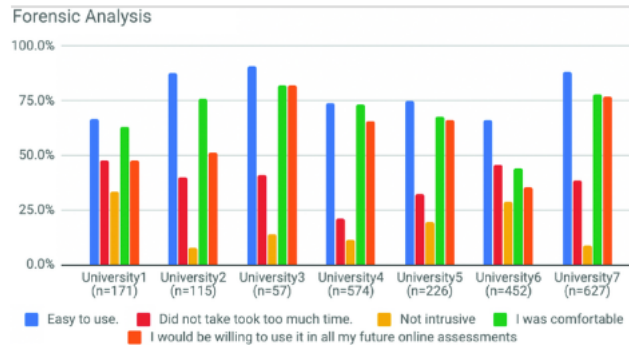
Fig. 8. Students 'opinions about forensic analysis instrument - data from post-questionnaire

### 4.5. ASSESSMENT DESIGN AND PEDAGOGY - How engaged are teachers and managers in assessment design, teaching, training and support with TeSLA system?

Various teaching staff agreed they were satisfied with the TeSLA experience particularly University 6 (70%) and University 5 (100%). Participants from two institutions were less satisfied than others (University 7 – 50% and University 4 – 25%). Although most of the participants agreed they received technical guidance, a smaller percentage agreed that technical problems were quickly and satisfactory solved particularly for University 3 (50%) and University 4 (0%).

Teachers were able to redesign and recreate new e-assessment activities supported by e-authentication. For some universities (3, 4, 7) the process of integrating the TeSLA instruments started at the course design stage. However, some teaching staff and course teams would have liked to obtain more guidance from the system about how best to combine the instruments and analyse their outcomes in order to use the instruments more effectively. In addition, some  Institutions did not have access to the results and would have liked additional support to interpret the instruments' outcomes. The negative factors that impact on their staff's experience with TeSLA was that the system failed or stop working properly (Universities: 1, 2, 4, 5 and 7) where the workload was greater than expected particularly for University 1 (75%) and University 4 (71%) and University 5 (40%).

### 4.6. AWARD BODIES AND POLICY MAKERS - Does TeSLA contribute to and support national education policy and social aspirations?

All pilot coordinators also mentioned that the university has in place procedures to deal with cheating and plagiarism, however, teaching staff must receive some guidance to interpret the feedback and know how to solve technical issues with the results.

In many institutions, policy makers confirmed that the implementation of TeSLA will be an opportunity to raise the profile of academic integrity within the institution. So that this might draw attention both to academic integrity policies and to quality assurance for e- learning.

Local regulations including policy development, education of staff and students, assessment practice and technology support will be important for all institutions interested in e-authentication. The technical team provided a few comments about the TeSLA technology providers' support:

- **Reducing delays for solutions**: *TeSLA technical team were very supportive during the whole pilot. They made a lot of efforts and spend a lot of time resolving our issues.*
- **Providing more documentation**: *Key developers were responsive via issue-tracker, e-mail and Skype. However, only two of the components had proper CHANGELOGs / release notes (I requested), and there was not consistent and low-level information within the code-base -- READMEs, API.md etc.*
- **Improving communication with schedule:** *There was an over-reliance on verbal communication in meetings, with no minutes, and instructions buried in communication forums. The development schedule and methodology were not well communicated to Pilot institutions.*

### 4.7. STAFF, RESOURCE AND FINANCIAL COSTS - What was the technological readiness of staff?

Technical teams were asked whether they have capacity to carry on using the system in their Institution after the TeSLA completion. Four institutions replied yes and provided comments:

- *My institution is working in a continuity plan.*
- *We need to test the final release and documentation to be sure about all the answers. They are now based on the current experience.*
- *We do have the expertise.*
- *We are able to use/test the TeSLA system after the project if the final version is technically stable enough and the technical support and version delivery are arranged properly.*

Five institutions (apart from 1 and 7) mentioned that there was more effort from the technical team than they expected during the pilot implementation because of the technical issues, delays and long period without getting an answer. The reasons were:

- **Lack of stable version before the pilot implementation:** *Technical teams are deploying TeSLA versions every week. This is not what was expected. Efficient way to proceed is having a stable version before the pilot implementation.*
- **Workload to report and solve issues with the system:** *When issues were raised with the instruments (especially with the enrolments) it needs a lot of efforts to report and resolve them. At the beginning of both phases of the 3rd pilot we put much efforts every day in order the pilot to start successfully.*
- **Lack of clear tasks for the technical team:** *My role was not well defined at the outset. As our Pilot studies were ALL remote and at a distance, I needed to: 1. customise core Moodle & TeSLA plugin language texts; 2. customise LTI-enrollment language texts; 3. deploy Moodle-TeSLA plugin, and TeSLA backend components; 4. liaise with developers, report bugs ...;*

*5. test the TeSLA plugin and functionality. One of the biggest challenges was reporting and mitigating bugs found when software was delivered late, with little or no time before pilots were due to start (late).*

- **Lack of plugin for a different VLE:** *The project promised to deliver a plugin that could be used in any VLE but could not do so. Consequently, we had to develop our own implementation on top of the planned resources. Even then, we had to develop quite some additional features.*
- **Lack of information and translated guidelines:** *We had problems with version management, translations and getting information of new features.*

The technical teams of the seven institutions provided support to pilot coordinators during pilot 3 which included: technical guidelines, solutions for endusers' technical problems, FAQ to support teaching staff and technical support for teaching staff with SEND.

The comments about their support were:

- *We had spent more resources that it was planned originally.*
- *We worked very close with the pilot leader and the technical guidelines and user manuals were result from our collaborative work.*
- *We tested together the system and we were supporting teachers and students collaboratively as well.*
- *As technical lead, I supported a lot of the Moodle course and activity configuration, supported writing Pilot-specific course content, documented and showed colleagues how to access TeSLA data, configured the TeSLA components, supported testing by the team.*
- *As far as I know, we had no way to specifically invite SEND students to participate in the Pilots.*

In terms of Institutional Leaders' views about the *TeSLA* system in authentication (staff, resource and financial costs, methodology and trust), six leaders would be willing to adopt an e-authentication system (e.g. TeSLA) for their institution. Three leaders would buy an e-authentication and plagiarism detection system for providing more flexibility and possibilities of e-assessments that are trustful. Their expectations and suggestions are a user-friendly system, a usable product, well-documented references, information about how the tools work and guidelines for interpreting results and detecting cheating. They mentioned some potential benefits: increase the opportunities for online teaching with e-assessment as part of their curricula, offer more possibilities for SEND students to complete assessment at home, improve quality and security of e-assessment.

They also indicate some potential challenges for their institution with the adoption of TeSLA such as: changing university regulations, potential resistance of some students or teachers, technical support and readiness, increasing capacity related to resource allocation and administrative staff support.

### 4.8. METHODOLOGY - What are the issues related to data collection and analysis, students´ consent, SEND participation?

Many students (more than 50%) indicated that they found the consent form (which gives permission by the student for the system to use their data which, in the case of TeSLA, can also include biometric data) easy to understand in all institutions. They

also indicated that the form provided enough information and they were confident with the way their personal data was being used by TeSLA. However, some students (20% to 40%) from most of the universities indicated a negative experience, i.e., 15% to 20% of students were unsatisfied with the amount of feedback that they received.

An average of 35% did not understand how the TeSLA system was used to e-authenticate their identities and checking their authorship. An average of 15% of students faced technical problems, apart from University 3 who used only a few instruments in pilot 3. (Figure 16).

The number of students who were unwilling to share any type of personal data was very small (less than 5%, apart from University 6 which was 15%). However, the number of students who were willing to share personal data are less than 25% in four institutions (1, 3, 4 and 5). This means that most students in these institutions are not sure if they want to share their personal data (See Figure 17). In contrast, there are two institutions whose 75% students are more willing to share their personal data (Universities 2 and 7).

### 4.9. TRUST - Do users feel informed, comfortable and confident with the TeSLA system?

Participants found in general that TeSLA system will increase trust in e-assessment. Students from all institutions provided their views about e-authentication and trust showing that they were informed, comfortable and feeling confident.

Most of them consider that e-authentication and authorship verification will increase trust on e-assessment particularly from Universities 2, 4, 6 and 7.

University 2: Preventing cheating is a good thing. Even though you're honest yourself, there's no guarantee that others are. *Of course e-authentication creates a sense of surveillance, but I do not think it is a negative thing*

University 4: *I think that participants will trust online assessment more than before.*

University 6: *The security measures are very important in spite of the connected to the internet devices. The results will be more secure.*

University 7: *It is important for the university to increase the trust between university, industry and students. Industry and society continue to mistrust fully online assessment mostly by preconception about online assessment*

There were also students that were more resistant and consider that e-authentication and authorship verification will not be enough to ensure trust particularly from Universities 1, 3 and 5.

University 1: *The measures taken will not be sufficient. There may be some difficulties in terms of reliability, validity and usability. Face-to-face evaluation is more appropriate for now.*

University 3: *Online assessment can be an option for certain situations. Too many variables, too much doubt if system will work reliable, not clear what is meant by online, not able to judge.*

University 5: *It is very difficult. Not any additional comments.*

In terms of Teachers' views about positive factors to promote trust on e-authentication and authorship verification, data from pre- and post-questionnaire data were very similar. Most participants from all institutions (more than 60%) selected positive factors particularly that it will increase the trust among universities and employers and it will help participants trust the outcomes of e-assessment.

The seven technical teams confirmed that the TeSLA technology providers supported them with information and guidance, including security and data protection information; apart from the extra documentation with support for a different platform (very little assistance).

In terms of impact, pilot coordinators were asked whether the TeSLA had impact on students who were previously unable to participate in assessments (e.g. for reasons of location, disability, lifestyle). Although many of them mentioned that there was not an impact yet; they presented a few benefits:

- *It will have a positive effect when the system is completed and ready to use.*
- *TeSLA system will provide new kind of possibilities and alternatives for students including SEND.*
- *TeSLA has been only used during continuous assessment.*
- *Most of the SEND students, as well as many students who live far from the university building were very happy that they could conduct their activities from home by using the TeSLA system. Their attitude towards the usage of such system was very positive before and after their experience with TeSLA.*

Five Institutional leaders mentioned that very frequently there is a need to authenticate students during assessment in their Institution. In addition, six leaders would be willing to adopt an e-authentication system (e.g. TeSLA) for their institution.

They were also asked whether there was any other system or approach that they would use instead of TeSLA. Some of them suggested: e-proctoring and National IT-solution. Three leaders mentioned that would buy an e-authentication system for their institution. Their views about the potential benefits of using e-authentication in their institution were:

- *To increase the cases of e-assessment and its quality.*
- *The opportunity to offer more flexibility for students.*
- *More secure; more possibilities for e-assessments; assessments at home.*
- *SEND students using the system at home without supervision.*
- *Trustful authentication and plagiarism detection system.*
- *Opportunity to introduce online teaching as part of the curricula offered on more regular basis.*

They were also asked about the potential challenges of using e-authentication in their institution. All of them mentioned various issues, such as:

- *Implement it to the entire university.*
- *Changing the university regulations.*
- *Resistance of some students or teachers for adopting a new system.*
- *Training needed for students and teachers to learn how to use a new system.*
- *Extra workload for establishing such a system, creating new procedures and guidelines.*
- *Technical issues (e.g. link to LMS and grading systems), governance (e.g. accreditation), trust (e.g. by teaching staff).*
- *Technical support form IT-services.*
- *Technical readiness of students to use TeSLA.*
- *Fanatical resources allocation and administrative staff support.*

Some Institutional leaders also presented their final comments about their expectations and suggestions:

- *A usable product / system including well-documented references.*
- *More information about how the tools work to devise appropriate assessments.*
- *Information about tools that are new for institutions such as Forensic analysis.*
- *The confidence values for detecting cheating.*
- *A very user-friendly system.*

## 5. Discussion and Conclusions

This work presented a novel approach: an Evaluation methodology for trust-based adapted systems by connecting Responsible Research and Innovation with Human-centred design approach. This methodology was applied and refined throughout three pilot studies which enabled the project team to measure and evaluate trust during the development of the innovative technology TeSLA.

The EU-funded *Adaptive Trust-based e-Assessment System for Learning* (*TeSLA*) (http://tesla-project.eu) was developed to check student authentication and authorship through a combination of various instruments, such as: facial recognition, voice recognition, keystroke analysis, plagiarism detection and forensic analysis.

The findings (Table 4) suggest a broadly positive acceptance of and trust in e-authentication for online assessments by both women and men, with neither group finding the e-authentication tools experienced to be either particularly onerous or stressful (Okada, Noguera et al., 2019).

Table 4. Summary of Findings related to the key thematic questions

| THEMATIC CATEGORIES | KEY THEMATIC QUESTIONS |
|---|---|
| 1. STUDENT PERSPECTIVES | Most of the student´s perceptions about e-authentication systems and TeSLA tools were positive. They selected various advantages in particular to prove that their work is authentic, to improve the rigour of assessment, to ensure trust and prevent cheating. Students from universities 4 and 7 listed various benefits including SEND participants. |
| 2. STAFF PERSPECTIVES | The educators´ views were positive, most of them would recommend it to other colleagues. However, there were some concerns in terms of students´ experience: personal data provided by all students; system working properly; enough time for students to complete e-assessment. In terms of TeSLA interface, they expected clear and accurate feedback, guidance and reliable results. |
| 3. TECHNOLOGY DEVELOPMENT | Most of the technical team´ views about the data and system integration presented various issues apart from |

| | |
|---|---|
| | University 7: time, audit data, technical problems, institutional constraints, documentation, settings, infrastructure, and technical support from the technology providers. |
| 4. EFFECTIVENESS OF THE AUTHENTICATION AND AUTHORSHIP | The results of e-authentication were not available to the Institutions, all Pilot Coordinators reported that they were not sure about the reliability of the system and whether the TeSLA instruments assisted the Institution in checking e-authentication. |
| 5. ASSESSMENT DESIGN AND PEDAGOGY | Teachers and managers were satisfied in supporting the assessment design, teaching and training with TeSLA system, in particular University 5 and 6. Most of the teachers agreed they received guidance. However, only a smaller percentage agreed that technical problems were quickly and satisfactory solved. |
| 6. AWARD BODIES AND POLICY MAKERS | Institutions mentioned that they have in place procedures to deal with cheating and plagiarism. However, teaching staff need some guidance about e-authentication to interpret the feedback and know how to solve technical issues with the results. The key requirements for policy makers at institutional level are: reducing delays for solutions, providing more documentation, and improving communication with schedule. |
| 7. STAFF, RESOURCE AND FINANCIAL COSTS | Four institutions replied that they have capacity to carry on using the system, but there was more effort from the technical staff than they expected because of the technology problems and the lack of guidelines. Six leaders would be willing to adopt an e-authentication system (e.g. TeSLA) for their institution, three of them would buy an e-authentication system. The potential challenges reported were: changing university regulations, potential resistance of some students or teachers, technical support and readiness, increasing capacity related to resource allocation and administrative staff support. |
| 8. METHODOLOGY | The methodological approach was accepted and understood by various participants (more than 50%) in terms of data collection and analysis including consent forms. The key issues were the lack of feedback about e-authentication results, technical problems faced and uncertainties about sharing personal data for e-authentication. |
| 9. TRUST | Various participants considered that were informed, comfortable and confident with the TeSLA system. There |

| | were only a few comments presenting resistance to trusting an e-authentication with authorship verification system, particularly from the universities that are not distant education institutions. |
| --- | --- |

Table 4 summarises the findings based on our key thematic questions. All online distance universities (4 and 7) trusted the system more and had less difficulty accepting and working with the tools comparing to the other institutions. Many students (more than 70%) considered that examination results will be trusted and that the essay's authorship can be verified. Only a few students (5% to 19%) faced technical problems in all institutions. Various teaching staff were satisfied with the system and highlight the importance of having technical issues faster and satisfactory solved. Technical teams recommended sufficient capacity including cloud solution and training. Course coordinators found that e-authentication enabled new types of assessments and opportunities to reduce academic malpractice. Institutional leaders who would be willing to adopt an e-authentication system expect user-friendly and usable system with guidelines for interpreting results.

Five features related to a "trust-based e-assessment system", which emerged during the medium-test-bed (Okada, Whitelock et. al. 2019), were confirmed during the large-study:

1. **The system will not fail or be compromised**: participants who faced technical problems received support and were able to complete the assessment tasks independently.
2. **Data will be kept safely and privately:** participants were informed about data security, privacy and safety which helped them share personal data and become more confident with the system.
3. **No adverse impact on assessment experience**: procedures were discussed including technical and pedagogical support in case the system did not recognise students' identity and authenticity.
4. **The system will not affect performance:** teaching staff provided alternatives about instruments particularly for students with special educational needs.
5. **The system will ensure fairness**: the e-authentication and authorship verification system provided opportunities for flexible, supportive and trustful e-assessment

Our findings show that TeSLA system might address the concerns highlighted by the literature on academic integrity in the digital age. Universities will not be compromising the public trust by allowing incidents of plagiarism to go unchecked (Gulli, Kohler, & Patriquin, 2007) when using a trust-based e-assessment with e-authentication. "*One of the casualties of academic misconduct is the general sense of broken trust; students, faculty members, university administrators, potential employers, and the general public agree on very little when it comes to plagiarism, but all seem to share the sense that their trust in some aspect of university has been violated*" Tyler Evans-Tokaryk (2014:1)

To conclude, the RRI with a human-centred design approach was designed to support the scalability, sustainability and societal desirability of a technological innovation (Von Schomberg, 2011). This methodological approach enabled the evaluation of the European TeSLA system during its development through a set of studies. Findings revealed that this approach was vital to examine the perceptions and needs of distinctive users about the e-assessment with e-authentication and authorship verification system.

Future work will be important to address the key issues reported by participants for increasing trust of e-assessment in Higher Education (ESG, 2015; van den Besselaar, 2017). In particular, more studies will be necessary to examine the reliability and accuracy of the TeSLA system including technology integration and technical support with new institutions.

## References

EC (2017). Responsible Research and Innovation. European Commission. Retrieved from https://ec.europa.eu/programmes/horizon2020/en/h2020-section/responsible-research-innovation

EC (2012). *Assessment of key competences in initial education and training: policy guidance.* Commission staff working document. European Commission. Retrieved from http://eose.org/wp-content/uploads/2014/03/Assessment-of-Key-Competences-ininitial-education-and-training.pdf

Leveson, N. G. (2000). Intent specifications: An approach to building human-centered specifications. IEEE Transactions on software engineering, 26(1), 15-35.

ESG (2015) *Standards and Guidelines for Quality Assurance in the European Higher Education Area Brussels, Belgium*. Retrieved from http://www.enqa.eu/wp-content/uploads/2015/11/ESG_2015.pdf

Evans-Tokaryk, T. (2014). Academic integrity, remix culture, globalization: a Canadian case study of student and faculty perceptions of plagiarism. Across Discipl, 11(2), 1-40.

Gulli, Cathy, Kohler, Nicholas, & Patriquin, Martin. (2007). The great university cheating scandal. *Maclean's*. Retrieved from http://www.macleans.ca/homepage/magazine/article.jsp?content=20070209_174847_6984.

Okada A. (2018) What are your views about technologies to support and assess writing skills?. OpenLearn Retrieved from [https://www.open.edu/openlearn/education-development/what-are-your-views-about-technologies-support-and-assess-writing-skills]

Okada, A. and Rodrigues, E. (2018) Open Education with Open Science and Open Schooling for Responsible Research and Innovation. In: Educação Fora da Caixa: tendências internacionais e perspectivas sobre a inovação na educação. (Org.) Texeira, C. S. & Souza, M. V. (v. 4). São Paulo: Blucher, 2018. 41-54

Okada, A.; Whitelock, D.; Holmes, W. and Edwards, C. (2019). e-Authentication for online assessment: A mixed-method study. British Journal of Educational Technology, 50 (2) pp. 861-875. Retried from https://onlinelibrary.wiley.com/doi/full/10.1111/bjet.12608, https://doi.org/10.1111/bjet.12608

Okada, A.; Noguera, I.; Aleksieva, L.; Rozeva, A.; Kocdar, S.; Brouns, F.; Whitelock, D. and Guerrero-Roldán, A. (2019). Pedagogical approaches for e-assessment with

authentication and authorship verification in Higher Education (http://oro.open.ac.uk/id/eprint/58380). British Journal of Educational Technology (early access).

Owen, R., Macnaghten, P., & Stilgoe, J. (2012). Responsible research and innovation: From science in society to science for society, with society. Science and public policy, 39(6), 751-760.

Salah, D., Paige, R.F., Cairns, P., 2014. A systematic literature review for agile development processes and user centred design integration. In: 18th International Conference on Evaluation and Assessment in Software Engineering (EASE)

Seffah, A., Gulliksen, J., & Desmarais, M. C. (Eds.). (2005). Human-centered software engineering-integrating usability in the software development lifecycle (Vol. 8). Springer Science & Business Media.

Simon, B., Sheard, J., Carbone, A., & Johnson, C. (2013). Academic integrity: differences between computing assessments and essays. Proceedings of the 13th Koli Calling International Conference on Computing Education Research. 23-32: ACM.

Stahl, B. C. (2013). Responsible research and innovation: The role of privacy in an emerging framework. *Science and Public Policy*, *40*(6), 708-716.

Stilgoe, J., R. Owen, P. Macnaghten (2013) 'Developing a framework for responsible Innovation' in Research Policy, Vol. 42, Issue 9, P. 1568–1580

Stödberg, U. (2012). A research review of e-assessment. Assessment & Evaluation in Higher Education, 37(5), 591–604. doi:10.1080/02602938.2011.557496

RRI-TOOL (2016). RRI-TOOL Project. https://www.rri-tools.eu/

Rubin, J., Chisnell, D., 2008. Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests. Wiley, Indianápolis , Indiana..

Van den Besselaar, P. A. A. (2017). Applying relevance-assessing methodologies to Horizon 2020.

Von Schomberg, R. (2011). Prospects for technology assessment in a framework of

responsible research and innovation'. 39–61. Springer. Retrieved from https://link.springer.com/chapter/10.1007/978-3-531-93468-6_2

## Glossary of terms

**Responsible Research and Innovation (RRI)** is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view to the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products (in order to allow a proper embedding of scientific and technological advances in our society). Von Schonberg (2011)

**Human-centred design (HCD)** is recognised as a significant approach for technology development and system evaluation through continual interaction with end-users to ensure that the innovation will address their needs and expectations.

**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.

**Plagiarism detection (PD):** 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.

## Index of terms

Responsible Research and Innovation (RRI)

Human-centred design

Trust-based e-assessment system

Academic integrity

Facial recognition

Voice recognition

Keystroke dynamics

Forensic analysis

Plagiarism detection