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TrustID 

University of Patras Multiplier Event  
Intellectual Output 3 - Evaluation Reports regarding Efficiency,  
Effectiveness and User Acceptance of TRUSTID in Three Case Studies  
at Higher Education Institutions across Europe

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University  
of Cyprus



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# Intellectual Output 3 (IO3)

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- Evaluation Reports regarding Efficiency, Effectiveness and User Acceptance of TRUSTID in Three Case Studies at Higher Education Institutions across Europe
- *Lead:* University of Cyprus
- *Participating Partners:*
  - University of Patras
  - Cognitive UX GmbH
  - University of Coimbra ISR
- *Output type:* Studies / analysis – Data collection / analysis
- *Media:* Dataset, Publications

# I03 – Key Objectives

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- Organize and execute **standalone studies and pilot trials**
- **Assess the effectiveness and accuracy** of the intelligent biometric methods
- Evaluate the overall effect of the project on **usability and security**
- Produce **evaluation reports**
- **Define personas** including the characteristics of the most representative end-users
- **Define different evaluation scenarios** of TRUSTID

# IO3 - Tasks and Task Leaders

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- **Task 3.1: Design of Experimental Evaluation Methodology**
  - **Lead: University of Patras**
  - *Participating:* University of Cyprus, Cognitive UX GmbH, University of Coimbra
- **Task 3.2: Formative Evaluation Report**
  - **Lead: University of Cyprus**
  - *Participating:* University of Patras, Cognitive UX GmbH, University of Coimbra
- **Task 3.3: Summative Evaluation Report**
  - **Lead: University of Cyprus**
  - *Participating:* University of Patras, Cognitive UX GmbH, University of Coimbra

## Task 3.1: Design of Experimental Evaluation Methodology

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- **Design the overall experimental methodology** to be followed throughout the course of the project
- **Ecological validity** (design a study that approximates the real-life contexts)
  - Design a series of user studies in which real users will be performing real-life tasks in their natural environment
- Studies with **balanced** gender (male/female), students, faculty and administrative staff of the University of Patras, the University of Cyprus and the University of Coimbra
- Two types of studies
  - **Formative**, conducted at early stages of the project, which aim at validating initial prototypes of the platform and get initial user feedback on likeability, perceived usability and security
  - **Summative**, conducted during the last months of the project to evaluate the effectiveness and feasibility of the proposed approach

## Task 3.2: Formative Evaluation Report

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- On completion of the low-fidelity development, semi-structured interviews were conducted to gather **qualitative user feedback for the low-fidelity release**
  - Based on feedback gathered from the previous cycle, we refined IO1 and IO2
- Upon completion of the second round of development, we conducted another round of studies to:
  - investigate whether the proposed system **improves identity and authentication usability and security**
  - evaluate **user acceptance** with Technology Acceptance Models to validate the developed user identification schemes

## Task 3.3: Summative Evaluation Report

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- We conducted the final evaluation aiming to **evaluate usability and user acceptance** of the proposed platform
- Various metrics were measured, which focused on capturing **qualitatively and/or quantitatively** the user's perceived usability and security, likeability and user acceptance
- The measurements were collected through **user feedback** (e.g., post-study questionnaires, interviews), and by examining **user interaction patterns** during user identification through user tracking equipment (e.g., Web camera, microphone, keyboard)

# User Study Scenarios for Proof of Concept 2



# Aims of the Evaluation

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We conducted a user study aiming to evaluate:

- i) the resilience of TRUSTID to impersonation attacks during an online examination by evaluating the implemented face- and voice-based identification mechanism;
- ii) usability and user experience of end-users based on their interactions with the TRUSTID system; and
- iii) perceived security and privacy of users towards the TRUSTID system

# Study Design 1/2

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## Type of study

- Studies were held virtually
  - Researchers from each partner HEI communicated with the participants through an off-the-shelf communication tool, Zoom

## Sample size, user profiles and duration

- Recruit 133 students and/or instructors per HEI
- *Duration*: ~20-30 minutes

## Preparation phase

- Invite participants through the following URL:
  - [https://trustid-project.eu/participate\\_upat.php](https://trustid-project.eu/participate_upat.php)
  - [https://trustid-project.eu/participate\\_uc.php](https://trustid-project.eu/participate_uc.php)
  - [http://trustid-project.eu/participate\\_ucy.php](http://trustid-project.eu/participate_ucy.php)
- Ask participants to subscribe to the PoC2 user evaluation study
  - Read information about the method of study, planned dates, etc.
  - Provide email so that we can communicate during the PoC2 study period

## Evaluation Phase

- **Step 1:** Participants download and install the implemented applications (Windows or MacOS)
- **Step 2:** Instructors enroll participants in the user study and they receive their login credentials in their email
- **Step 3:** Evaluate specific threat scenarios and functionalities
  - *Type of examination:* Digital oral, Digital written
  - *Impersonation threats*
    - Perform the student verification step based on *face-based* and *voice-based* identification
    - Continuous student identification based on *face* and *voice* data
  - *Collaboration/communication threats*
    - Monitoring the students' computing device's running applications and processes
  - *Other functionalities:*
    - Management of biometric models (Enroll/Update/Delete)
    - Integration of the new version of face-based identification which uses GRPC
    - Management of Examinations and LMS integration
      - Moodle integration - fetch students' information and automatically enroll to TRUSTID
      - Instructors upload .csv with students' information exported from other LMS
      - Add/Update examination to the TRUSTID system
- **Step 4:** Conduct semi-structured interviews and focus groups to receive feedback from the participants about their experience with the TRUSTID solution

# Study Registration

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The screenshot shows the TRUSTID website's 'Participation in a User Study in the frame of the TRUSTID Project' page. The page features a navigation menu with links for 'WELCOME', 'ABOUT TRUSTID', 'CONSORTIUM', 'VIDEOS', 'INTELLECTUAL OUTPUTS', 'NEWS', and 'PUBLICATIONS'. The main content area is titled 'Participation in a User Study in the frame of the TRUSTID Project' and includes a 'DESCRIPTION' section. The description explains the project's goal of evaluating the TRUSTID application and provides instructions for participation, including a requirement for a computer and web camera. A 'LATEST NEWS' sidebar on the right lists several events, such as a 'Biweekly Meeting' in September 2022 and a 'Dissemination Workshop' in July 2022.

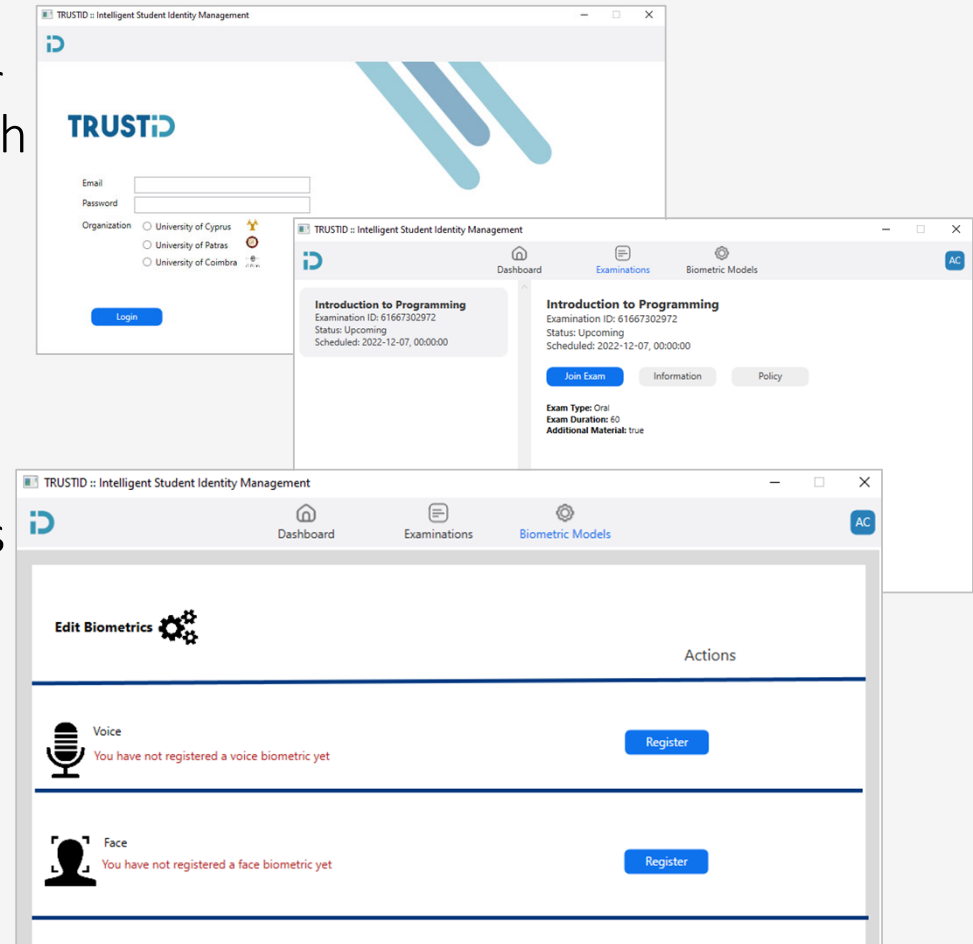
The screenshot shows the TRUSTID website's subscription form. The form is titled 'SUBSCRIBE ON BEHALF OF THE UNIVERSITY OF COIMBRA, INSTITUTE OF SYSTEMS AND ROBOTICS' and includes a 'FULL NAME' field, an 'EMAIL' field, and an 'OPERATING SYSTEM' dropdown menu. A 'SUBSCRIBE' button is located below the form. To the right of the form, there is a 'TRUSTID has a new logo' notification with a date of December 22, 2021, and a 'Paper Acceptance' notification with a date of November 20, 2021. Below the form, there is a section titled 'RESEARCH ETHICS AND PRIVACY OF PERSONAL DATA' which provides detailed information about data handling and privacy.

# Scenario 1 – Student Biometrics Enrollment

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- Once the students log in to the system with their credentials, they select their examination through the TRUSTID dashboard
- Students are requested to enroll their biometrics (e.g., face, voice) through the biometric models management screen

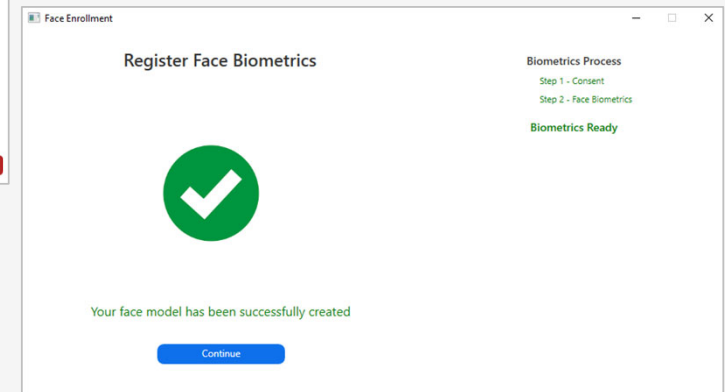
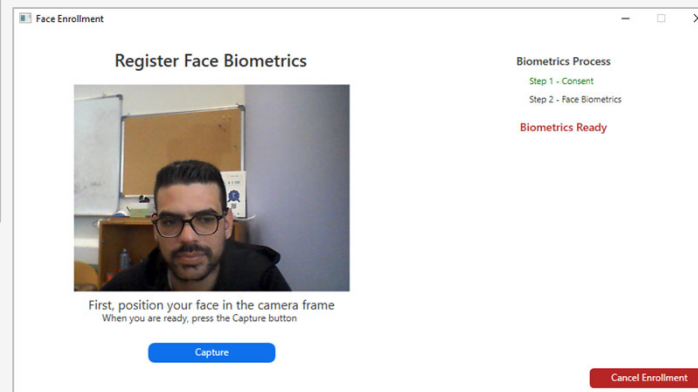
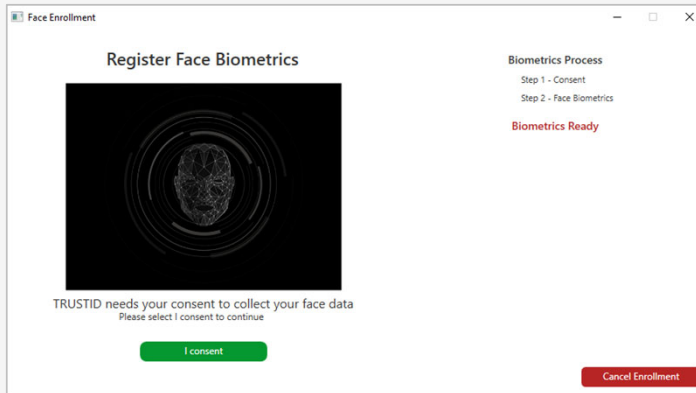


# Scenario 1 – Student Biometrics Enrollment (Face)

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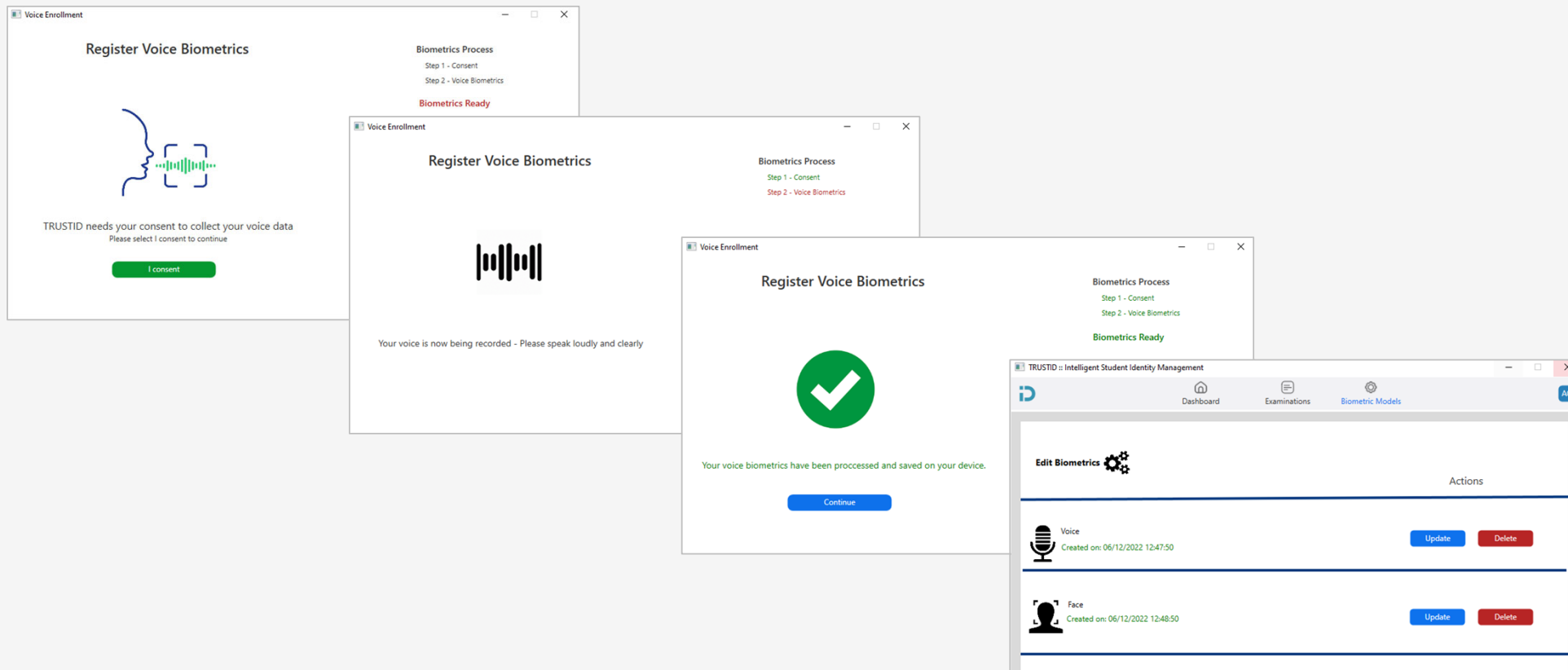


- The TRUSTID app captures student's face data and generates the face model



# Scenario 1 – Student Biometrics Enrollment (Voice)

- The TRUSTID app captures student's voice data and generates the voice model



The image displays a sequence of four screenshots illustrating the voice biometrics enrollment process in the TRUSTID app:

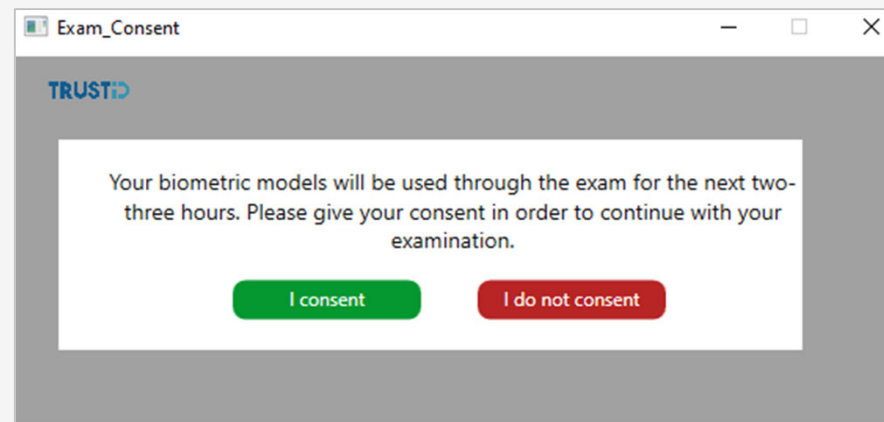
- Consent Screen:** Titled "Register Voice Biometrics", it shows a profile icon and a green "I consent" button. Text: "TRUSTID needs your consent to collect your voice data. Please select I consent to continue".
- Recording Screen:** Titled "Register Voice Biometrics", it shows a microphone icon and the instruction: "Your voice is now being recorded - Please speak loudly and clearly".
- Success Screen:** Titled "Register Voice Biometrics", it features a large green checkmark and the message: "Your voice biometrics have been processed and saved on your device." with a "Continue" button.
- Management Dashboard:** Titled "TRUSTID :: Intelligent Student Identity Management", it shows a table of biometric models under "Edit Biometrics". The table has columns for "Voice" and "Face", each with "Update" and "Delete" buttons. The "Voice" entry is created on 06/12/2022 12:47:50, and the "Face" entry is created on 06/12/2022 12:48:50.

## Scenario 2 – Student Identity Verification

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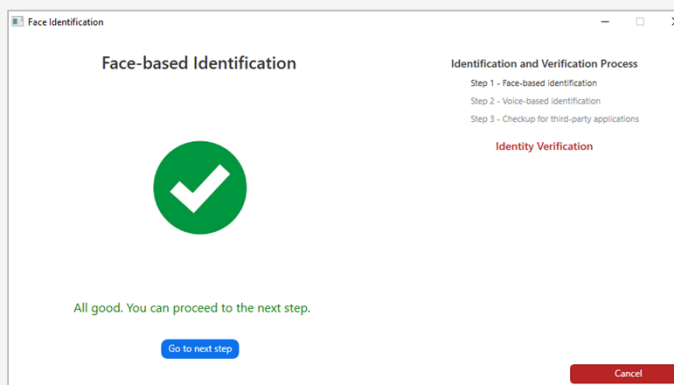
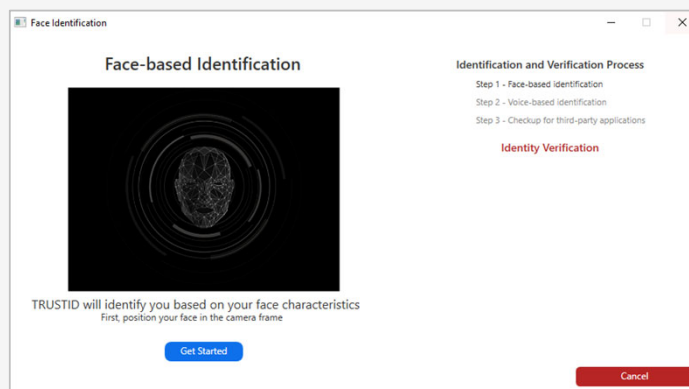
- Before initiating the examination, the student provides their consent to use their biometric models, and they then go through the identity verification step in which they are identified through the implemented face- and voice-based identification mechanisms





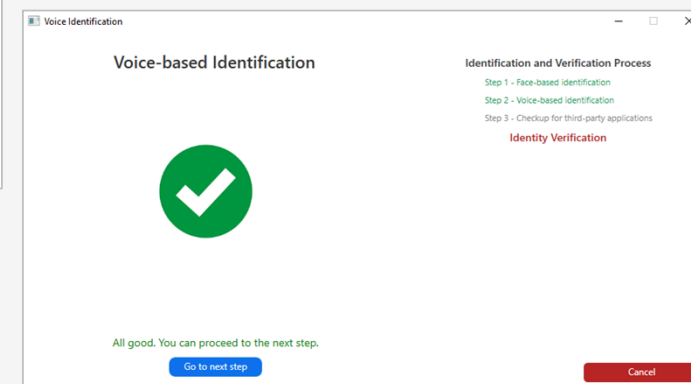
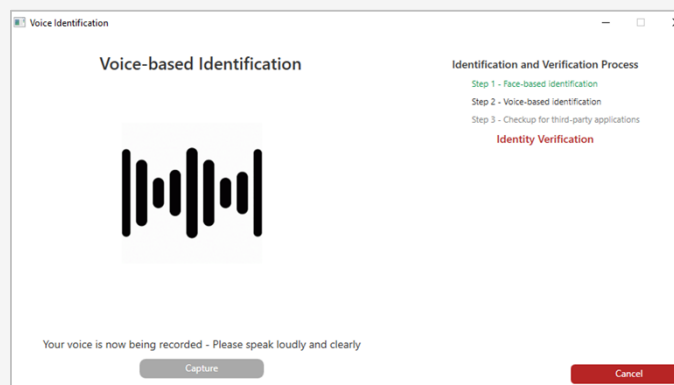
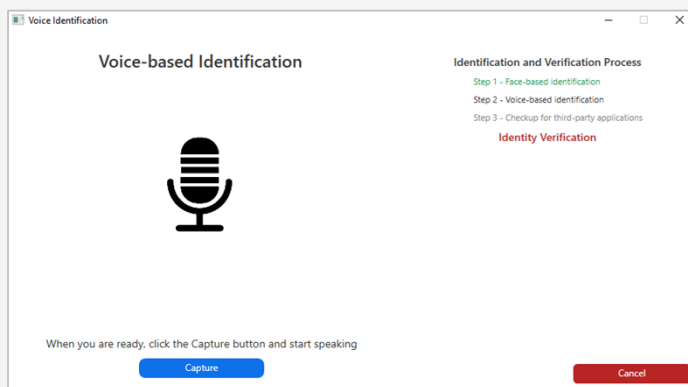
# Scenario 2 – Student Identity Verification (Face)

- Students are requested to misuse the system, e.g., use impersonation, in which another person sits in front of the camera to verify their identity



# Scenario 2 – Student Identity Verification (Voice)

- Students are requested to misuse the system, e.g., use impersonation, in which another person speaks to the microphone to verify their identity

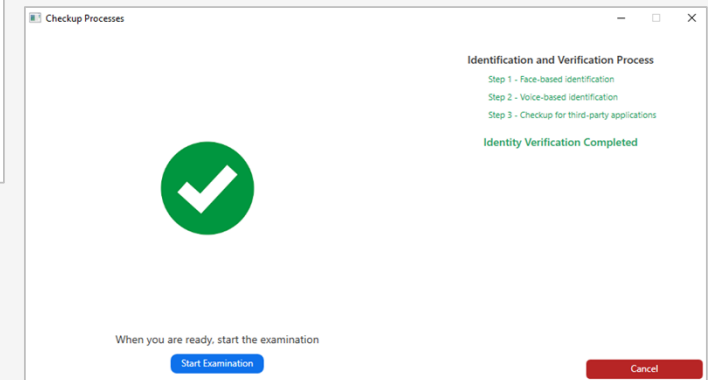
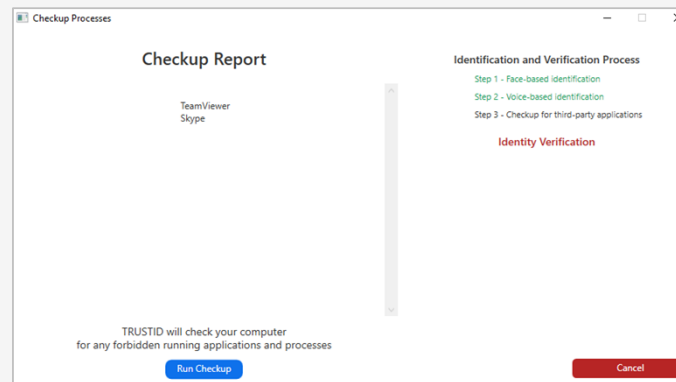
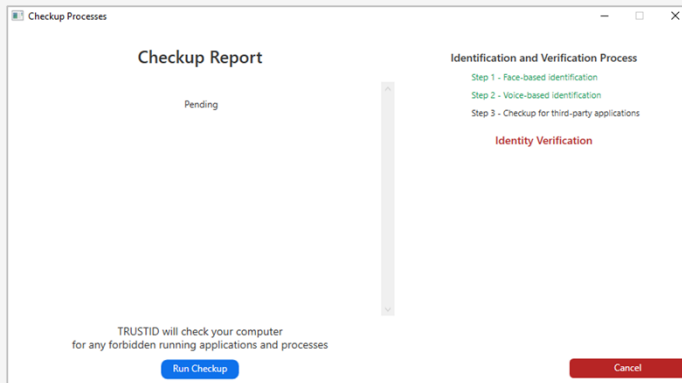


# Scenario 2 – Student Identity Verification (Checkup Forbidden Applications)

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- Students are requested to misuse the system, e.g., use communication/collaboration tools prior to joining the examination

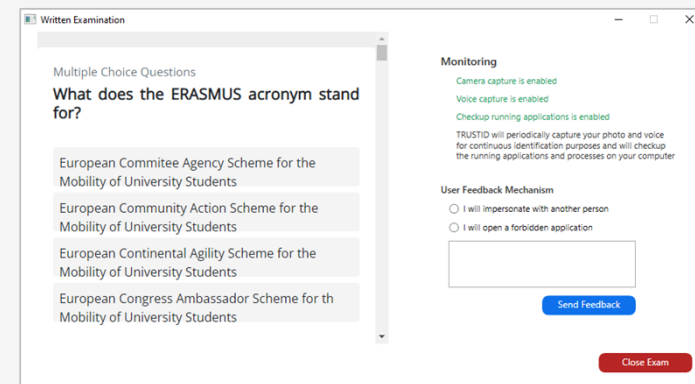


# Scenario 3 – Continuous Student Identification

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- The system continuously identifies the students through the continuous face- and voice-based identification mechanism
  - Students are requested to misuse the system, e.g., use impersonation, in which another person sits in front of the camera or speaks to the microphone to verify their identity

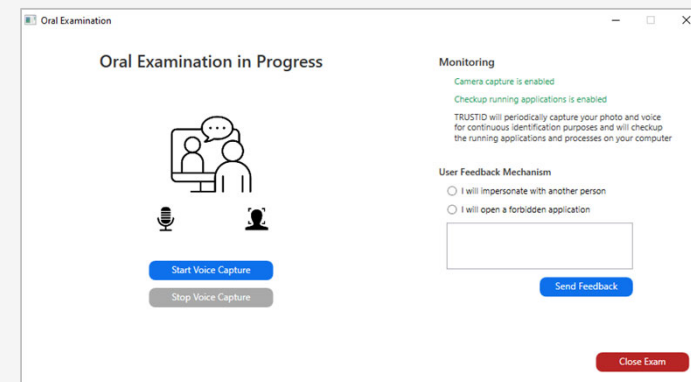


# Scenario 4 – Monitoring the Student’s Computing Device

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- Monitoring the students’ computing device’s running applications and processes
  - Students are requested to misuse the system, e.g., by asking them to open communication/collaboration tools during the examination session



# Scenario 5 – Examination Management for Instructors

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## - Add/Update examination

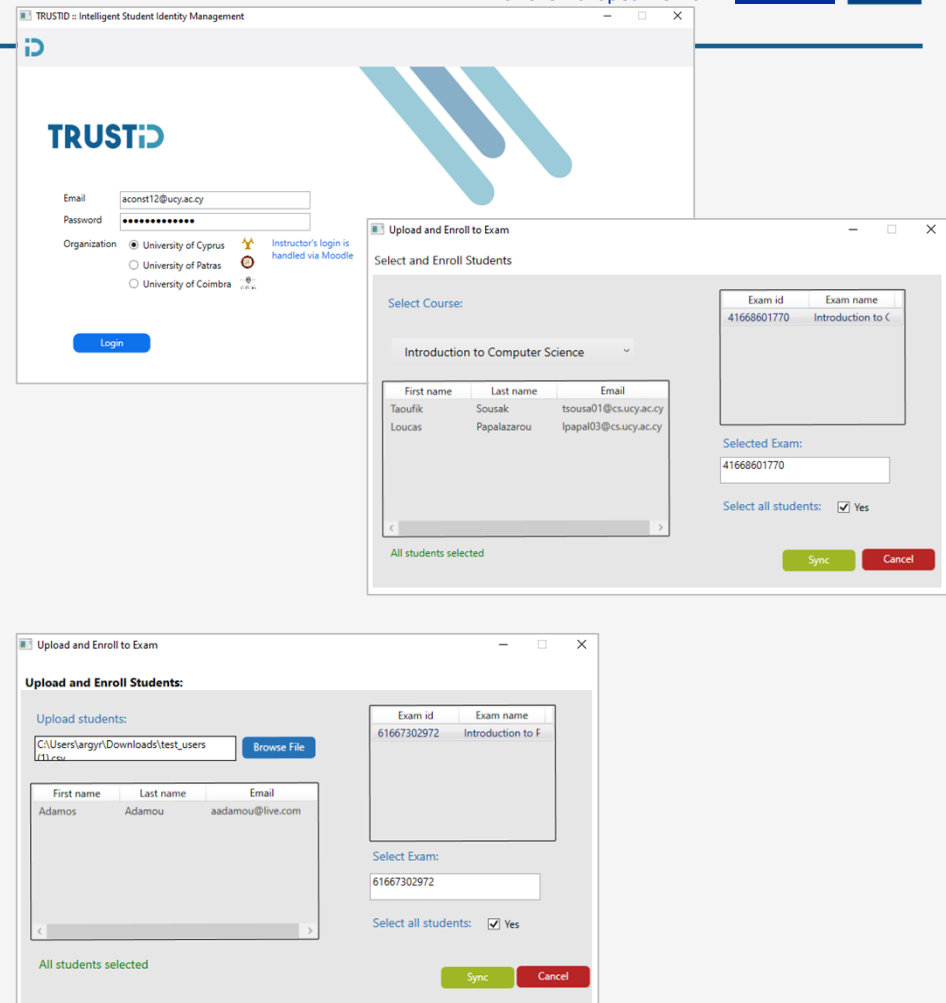
The screenshot displays the TRUSTID Intelligent Student Identity Management interface. The main window shows the 'Examinations' section with a list of exams for 'Introduction to Programming'. The 'Management' tab is active, showing options to 'Add a new exam', 'Edit existing exams', and 'Enroll students to exam'. Two modal windows are open: 'Add Exam' and 'Update Exam'. The 'Add Exam' form includes fields for 'Additional Material' (checkbox), 'Exam Duration', 'Exam Type' (dropdown), 'Name', 'Privacy Policy', and 'Scheduled date'. The 'Update Exam' form is pre-filled with 'Additional Material' checked, 'Exam Duration' 60, 'Exam Type' Oral, 'Privacy Policy' 'The privacy policy of the exam', and 'Scheduled date' 07/12/2022.

# Scenario 6 – LMS Integration

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- Moodle integration
  - Fetch students' information and automatically enroll to TRUSTID
- Instructors upload .csv with students' information exported from other LMS



# Resilience to Impersonation Attacks

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## Summary of the sample and the collected data

Mock Examination Type	# of Participants	# of Face Images	Audio Samples Length (in minutes)
<i>Online Written</i>	65	1804	75.68
<i>Online Oral</i>	68	1530	123.47
<b>Totals</b>	<b>133</b>	<b>3334</b>	<b>199.15</b>

## Summary of the sample and the collected data for impersonation attacks

Mock Examination Type	# of Participants	# of Face Images	Audio Samples Length (in minutes)
<i>Online Written</i>	24	391	31.04
<i>Online Oral</i>	32	582	52.73
<b>Totals</b>	<b>56</b>	<b>973</b>	<b>83.77</b>



# Summary of the results for each identification case

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Identification Case	Face Recognition (Success Rate)	Voice Recognition (Success Rate)
<i>Student identification in order to join examination</i>	100%	100%
<i>Continuous student identification prior to performing an impersonation attack</i>	94.80%	91.36%
<i>Continuous student identification while performing an impersonation attack</i>	76.57%	78.53%

# Questionnaire Results

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Question	Disagree	Moderate	Agree
Overall, how simple and clean is the TRUSTID software's user interface?	3	10	89
Overall, how intuitive to navigate is the TRUSTID software's user interface?	2	11	89
Overall, what's your opinion on the way features and information in the TRUSTID software are laid out?	5	10	87
Overall, how secure do you find the face identification process?	9	22	71
Overall, how secure do you find the voice identification process?	12	23	67
Overall, do you like the idea to be identified with face-based biometric identification during an online examination?	21	20	61
Overall, do you like the idea to be identified with voice-based biometric identification during an online examination?	26	24	52

# Key Findings

## *What worked well in PoC2:*

- The System Usability Score was calculated to be 78, which is a high score (Any score above 68 is considered above average[1]).
- Face enrollment.
- Face identification in both the registration and continuous monitoring phases.
- Continuous monitoring of running processes and detection of forbidden communication/collaboration tools.

## *Improvements for PoC3:*

- Voice enrollment and voice identification issues in some cases. Relevant quotes:

*“The voice registration wasn't successful the first few times” ~ P6*

*“The voice registration did not work, I had to change my default microphone input in windows for it to work” ~ P7*

## *Additions for PoC3:*

- *Privacy-preserving wallet mobile application*
- *Keystroke dynamics component*

[1] <https://www.usability.gov/>

# Publications

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Christos A. Fidas, Marios Belk, Argyris Constantinides, David Portugal, Pedro Martins, Anna Maria Pietron, Andreas Pitsillides, and Nikolaos Avouris. 2023. **Ensuring Academic Integrity and Trust in Online Learning Environments: A Longitudinal Study of an AI-centered Proctoring System in Tertiary Educational Institutions.** *Education Sciences* (2023). (to appear)

José N. Faria, David Portugal, Pedro Martins, Marios Belk, Argyris Constantinides, Andreas Pitsillides, and Christos A. Fidas. 2023. **Image-based Face Verification for Student Identity Management — the TRUSTID Case Study.** In *UMAP '23 Adjunct: Adjunct Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization* (UMAP '23 Adjunct), June 26–29, 2023, Limassol, Cyprus. ACM, New York, NY, USA, 6 pages. <https://doi.org/10.1145/3563359.3597397> (to appear)

Argyris Constantinides, José Faria, Taoufik Sousak, Pedro Martins, David Portugal, Marios Belk, Andreas Pitsillides, and Christos A. Fidas. 2023. **TRUSTID: Intelligent and Continuous Online Student Identity Management in Higher Education.** In *UMAP '23 Adjunct: Adjunct Proceedings of the 31st ACM Conference on User Modeling, Adaptation and Personalization* (UMAP '23 Adjunct), June 26–29, 2023, Limassol, Cyprus. ACM, New York, NY, USA, 4 pages. <https://doi.org/10.1145/3563359.3597410> (to appear)

Argyris Constantinides, Christodoulos Constantinides, Marios Belk, Christos A. Fidas, and Andreas Pitsillides. 2021. **Applying Benford's Law as an Efficient and Low-cost Solution for Verifying the Authenticity of Users' Video Streams in Learning Management Systems.** In *IEEE/WIC/ACM International Conference on Web Intelligence and Intelligent Agent Technology* (WI-IAT '21). Association for Computing Machinery, New York, NY, USA, 563–569.

Christos Fidas, Marios Belk, David Portugal, and Andreas Pitsillides. 2021. **Privacy-preserving Biometric-driven Data for Student Identity Management: Challenges and Approaches.** In *Adjunct Proceedings of the 29th ACM Conference on User Modeling, Adaptation and Personalization*. Association for Computing Machinery, New York, NY, USA, 368–370.

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# Thank you!

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