

I have a Dream: AI to Help Dyslexic People in Education

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A brief self-presentation



- Associate Professor at Universitas Mercatorum, Rome
- Faculty of Technological Sciences, and Innovation
- Teacher in several computer science courses
- Research Interests:
 - Artificial Intelligence applied to Education, to distance learning
 - Learning Analytics

Universitas Mercatorum



- A telematic and private university
- 50,000 enrolled students
- 32 degree courses
- 55 examination locations in Italy
- 72 professors (full+associate)
- 12 Researchers
- 26 Ph.D. students
- MOOCs

The AI4DX Project (14-RIC/FIN)

- Start date: April 1st, 2023
- End Date: May 31th, 2024
- **Building an Intelligent Chatbot for helping Dyslexic people to learn**
- Principal Investigator: Filippo Sciarrone
- Research group:
 - Prof. Temperini Marco (Sapienza University of Rome, Italy)
 - Assistant Professor Dabaghi Karma (American University in Beirut, Lebanon)
 - Prof. Nakayama Minoru (Tokyo University)
 - Dr. Stefano D'Urso (PH.D. student)
- To be implemented in Mercatorum's e-learning platform

- ❑ **MOOCs**
 - ❑ **Characteristics**
- ❑ **Current Trends**
- ❑ **Special Education**
 - ❑ **General Characteristics**
 - ❑ **Classification**
- ❑ **MOOCs and Special Education**
- ❑ **Artificial Intelligence and Special Education**
- ❑ **Some examples**
- ❑ **Conclusions**

Distance Education

- In recent years, especially during and after the **COVID-19** pandemic, the number of courses students have taken by distance learning has grown exponentially at all levels of education
- Schools, universities, and companies have radically changed the way they make didactic materials available and interact with learners (Kara,2021)
- Consequently, **new didactic strategies** of teaching and learning have made it possible to overcome the classical barriers of space and time and have launched new challenges for all stakeholders involved in educational processes (Da Tao, 2019)



Distance Education

- **MOOCs: Massive Open Online Courses**
- A popular way for people around the world to access high-quality educational content from reputable institutions for free or at a low cost
- They cover a wide range of subjects, from computer science and engineering to humanities and social sciences
- Courses with **thousands** of enrolled learners
- Examples:
 - Khan Academy
 - Coursera
 - FutureLearn
 - ...

Distance Education

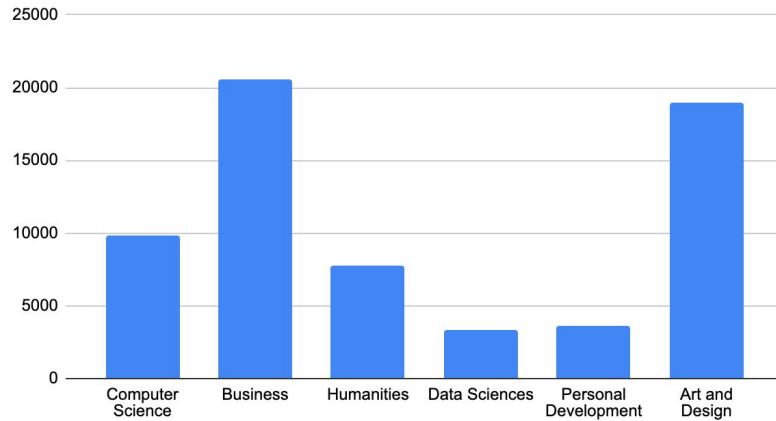
MOOCs main characteristics

- Accessibility
- Flexibility
- Variety
- Credentialing
- Community
- Technology-Driven
- Partnerships
- Continuous Update
- ...

(Kennedy,2014;Da Tao, 2019)

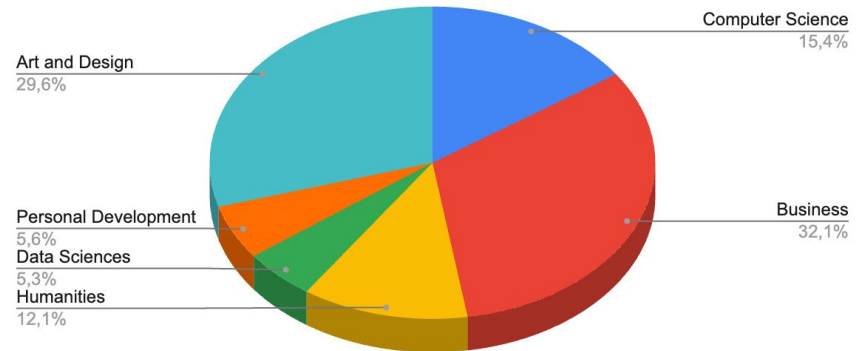
MOOCs

MOOCs Distribution



Absolute distribution

MOOCs Distribution



Relative distribution

MOOCs



 class central

By the Numbers: MOOCs in 2021
Statistics do not include China

2021: 220,9 Millions enrolled students

MOOCs' limit



In a distance education context it is difficult, if not impossible, for the teacher **to teach in a personalized way** and still ensure students' learning happens faster and more profitable

(Peng and Spector, 2019)

Some relevant literature

- Stracke, C.M.; Trisolini, G. A Systematic Literature Review on the Quality of MOOCs. *Sustainability*, **13**, 5817, 2021.
- Badali, M., Hatami, J., Banihashem, S.K. *et al.* The role of motivation in MOOCs' retention rates: a systematic literature review. *RPTEL* **17**(5), 2022.
- Stracke, Christian M., Downes, Stephen, Conole, Grainne, Burgos, Daniel, Nascimbeni, Fabio. *Open Praxis*, **11**(4), p.331-341. Oct-Dec 2019.
- Dilrukshi Gamage, Thomas Staubitz & Mark Whiting. Peer assessment in MOOCs: Systematic literature review, *Distance Education*, **42**:2, 268-289 (2021).
- Sciarrone, F., Temperini, M.: K-openanswer: a simulation environment to analyze the dynamics of massive open online courses in smart cities. *Soft Computing*, **24**(15), 11121 – 11134 (2020).

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Special Education

Special Education



Specific Learning Disorders

- Dyslexia
- Dysorthographia
- Dyscalculia
- Dysgraphia
- Dysphasia
- Dyspraxia
- ...

Special Education

- Specific Learning Disorders (**SLDs**) are neurodevelopmental disorders that can affect the brain's ability to receive, process, store, respond to, and communicate information
- Individuals with SLDs may struggle with skills like **reading, writing, math, reasoning, listening, and speaking**
- It's important to note that SLDs **are not due to a lack of intelligence or desire to learn**. With the right support and interventions, such as **specialized teaching methods**, technology, and accommodations, individuals with SLDs can achieve academic success
- The diagnosis and identification of specific learning disorders involve a comprehensive assessment that looks at the individual's abilities and struggles in detail

Special Education

- The American Psychiatric Association's DSM-5 categorizes SLDs into three main areas:
 - **Dyslexia**: this is perhaps the most well-known SLD and involves difficulties with **accurate and/or fluent word recognition, poor decoding abilities, and spelling difficulties**
 - **Dyscalculia**: this disorder affects a person's ability to **understand numbers and learn math facts**. Individuals with dyscalculia may struggle with calculation and performing math operations
 - **Dysgraphia**: This involves difficulties with **written expression**, such as composing written content, **spelling**, and **handwriting**. Individuals with dysgraphia may struggle with the physical act of writing or with organizing their thoughts on paper

SLD in Italy

- In Italy it is estimated that there are almost **three million people** with SLD
- Moreover, at school, what emerges from the latest report issued by the Ministry of Education is that there is a progressive increase in the number of students diagnosed with SLD
- Over the last two years, students diagnosed with a SLD were **318,678** and **326,548**, respectively, that is **5.3%** and **5.4%** of the total number of Italian students.
- Mainly these students were in years III, IV and V of primary school, and years I and II of high school, all with appropriate medical certification

SLD in Italy

- In 2010, a law was passed, **Law 170/2010** for teaching students with SLD in all schools
- In 2010, a law was passed, Law 170/2010 for the teaching of students with SLD in all schools, from primary to high school.
- It provides that a student with SLD has a Personalised Didactic Plan (PDP), constructed by the teachers of his or her class
- The PDP provides compensatory and dispensatory measures for each student with SLD
 - Evaluation must take into account **personalization**

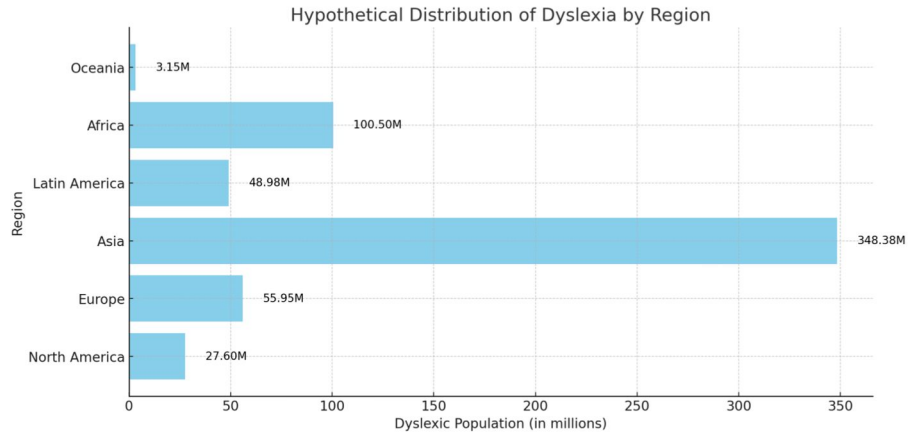
SLD in Europe

- According to the *European Dyslexia Association* (EDA), other European countries' epidemiological estimates of SLD are between **5%** and **12%** of the entire population
- Furthermore, the latest revision of the American Psychiatric Association's Diagnostic and Statistical Manual (APA, DSM V, 2013) raised the prevalence estimates for these disorders from **2-10%** to **5-15%**
 - Mazefsky, C., McPartland, J., Gastgeb, H., Minshew, N.: Brief report: Comparability of dsm-iv and dsm-5 asd research samples. *Journal of autism and developmental disorders* 43 (2013) 1236–1242

Dyslexia

- Among the SLD, dyslexia is the most common in the population worldwide, as stated by EDA (5%-20% of population):
 - *No matter which country – No matter which language – Dyslexia is everywhere.*

Dyslexia



Category	Dyslexia Statistic
Dyslexia Prevalence	1 out of 10 people
Number Of U.S. Adults With Dyslexia	40+ million
Most Common Learning Disability	Dyslexia
Men vs. Women Prevalence	60%, 40%
% Of U.S. Kids In School With Dyslexia	20%
Percent Of NASA's Workforce With Dyslexia	Over 50%

<https://www.crossrivertherapy.com/research/dyslexia-statistics>

Dyslexia

- Dyslexia is explained as a **deficit** in the manner phonological information gets processed, which affects the manner with which students recognize **words** and read as well as the way they produce words or spell
- The most widely accepted theory is that **it is caused by difficulties** in phonological processing
 - verbal working memory, rapid naming and sequencing skills are also affected
- There is **no relationship** between a person's level of intelligence, individual effort or socio-economic position and the presence of dyslexia

Dyslexia

- Dyslexia is essentially a neurological disorder and is the most common of all neuro-cognitive disorders
 - This makes it **incurable**
- While dyslexia cannot be cured, it is possible for individuals with dyslexia to make **significant progress** and improve their reading, writing, and spelling skills
 - van der Leij, A.: Dyslexia and early intervention: What did we learn from the dutch dyslexia programme? Dyslexia 19(4) (Oct 2013) 241–255
- With ongoing support and practice, many individuals with dyslexia are able **to overcome** their challenges and achieve their goals.

Dyslexia

Some relevant Literature

- Tijms, J.: Verbal memory and phonological processing in dyslexia. *Journal of Research in Reading* 27(3) (Aug 2004) 300–310
- Beitchman, J.H., Young, A.R.: Learning disorders with a special emphasis on reading disorders: A review of the past 10 years. *Journal of the American Academy of Child Adolescent Psychiatry* 36(8) (Aug 1997) 1020–1032
- Patience, T., Gilchrist, P., Thornes, N. (1997). *Dyslexia. A Multidisciplinary Approach*. Nelson Thornes Ed.
- Kearns, D.M., Hancock, R., Hoeft, F., Pugh, K.R., Frost, S.J.: The neurobiology of dyslexia. *Teaching Exceptional Children* 51(3) (Jan 2019) 175–188



MOOCs and Dyslexic Learners



MOOCs for dyslexic people

The problem

- In MOOCs learners **do not have** a one-to-one relationship with teachers
 - It is impossible for teachers to personalize their students' learning process
 - It is impossible to support single dyslexic learners
- **How can dyslexic learners be supported in MOOCs?**
- This is our research question we are investigating in the AI4DIX project

MOOCs for dyslexic people



The challenge (AI4DIX)

- To use Technology Enhanced Learning to assist dyslexic students. In particular:
 - Artificial Intelligence for Intelligent Conversational Agents (ChatBot)



AI, Education and Dyslexia:
the state of the art

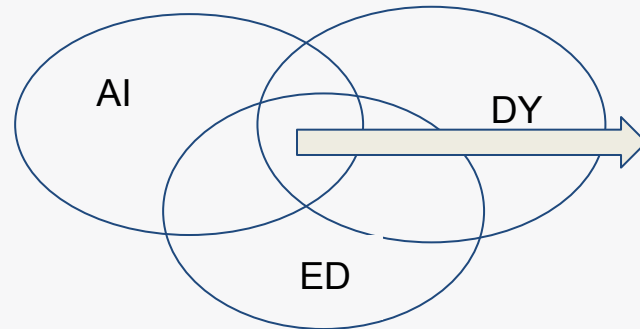


AI and Dyslexia

- Artificial Intelligence has been contributing to the improvement of learning support systems for years, from the Intelligent Tutoring Systems (ITS) to the latest generation of intelligent chatbots such as ChatGPT
- Machine Learning has been the most used approach to build support systems for dyslexic students
- We conduct a **review of the literature** concerning the use of AI for assisting dyslexic students during their learning process
 - in the range 2018-2023 (from generative AI)
- Main goal: helping dyslexic students through AI methods and techniques

AI and Dyslexia

- We used the **PRISMA** method for the reviewing process
 - *Preferred Reporting Items for Systematic Reviews and Meta-Analyses*
- We considered articles that proposed help for students with dyslexia, both on a theoretical level and on a practical level i.e., through intelligent support systems, as important for our research



RQ: Do these three fields meet?

The information sources

Sources

- IEEE
- Springer
- Arxis
- Elsevier
- Google Scholar

Period

- From 2018 to 2023 (after generative AI)

Papers in English language only and coming from Conferences and journals

The search strategy

- Searching for relevant articles situated at the intersection of **AI**, **dyslexia**, and **education**
- The following query was used:

"artificial intelligence" AND "dyslexia" AND "education"

- We (manually) classified the retrieved papers into six semantic categories
 - Cleaning step

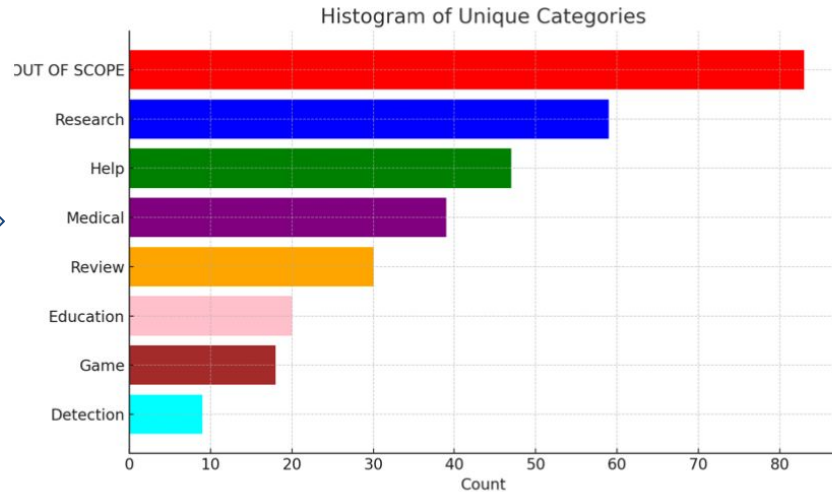
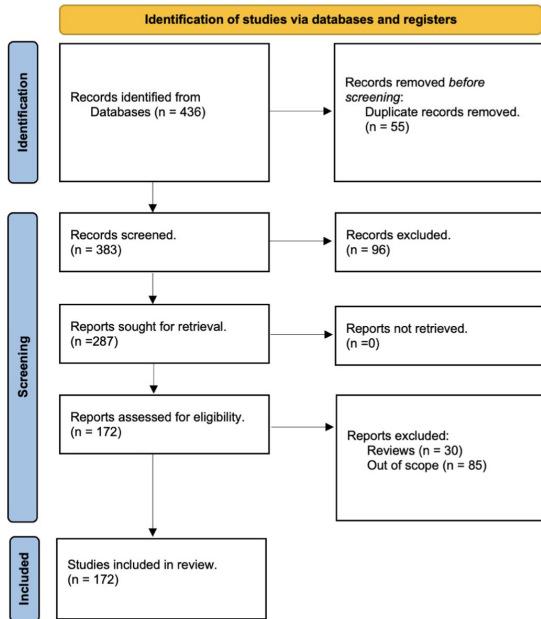


Search Categories

- **Research:** articles primarily engaged in research discussions on the theme
- **Help:** articles centered on the development and usage of tools aiming at assisting learners with dyslexia
- **Medical:** articles with a medical orientation, exploring the physiological aspects of dyslexia
- **Review:** Articles offering a review of existing literature and studies on the topic
- **Education:** Articles reporting on experimentation or application in the educational field, be it at the school or university level
- **Gaming:** Articles exploring gamification approaches to support individuals with dyslexia
- **Dyslexia Detection:** Articles focused on innovative methods and techniques to detect dyslexia

Results

- 436 records retrieved



The selection process

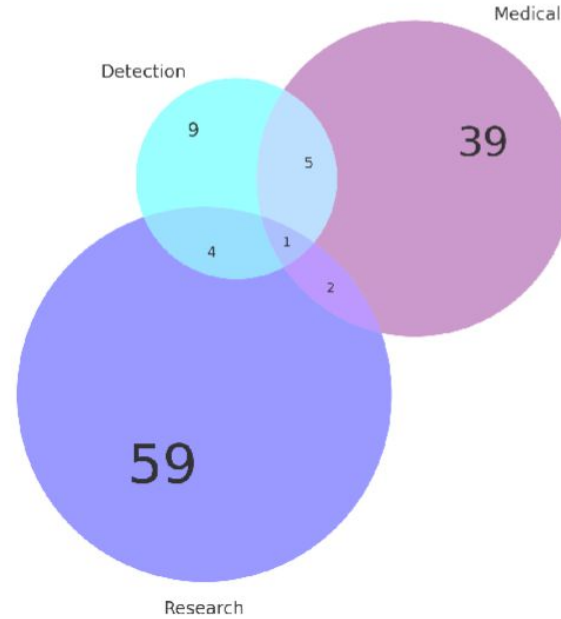
- The methods used to decide whether a study met the inclusion criteria of the review was based on the reading of the **title**, the **abstract**, the **keywords** and the **meta-data** associated to each paper, with the aim of conducting a binary initial screening of each paper into categories of good or not good
- Each paper was first analyzed and after discussed in a plenary session
- Google drive was used as the working area and Google sheet as the tool to build graphs and statistics.

Results

Research-Help-Medical

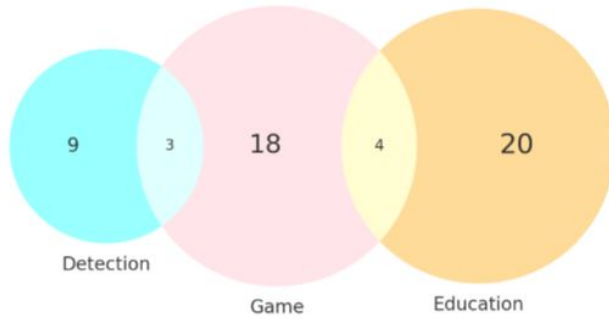


Research-Medical-Detection

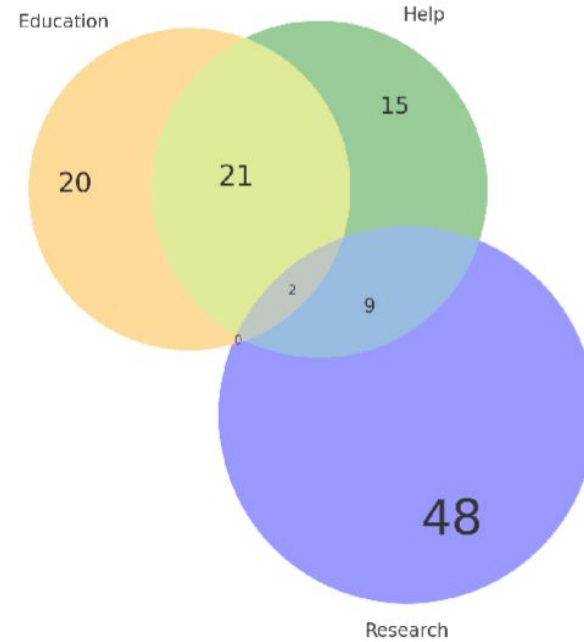


Results

Game-Education-Detection



Education-Help-Research



Remarks



- To date, generative AI **has not been used** to help dyslexic students
 - Machine learning techniques were used mainly for Dyslexia detection
 - There is a lack of proposals about AI for dyslexic students in the education field
 - **No papers really match AI+ED+DY**
- (Dabaghi, D'urso and Sciarrone, 2023)

Some recent papers

chatGPT and education

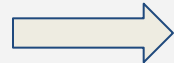
- Can ChatGPT empower people with **dyslexia**? (Botchu et al., 2023)
- What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature (LO, 2023)
- Revolutionizing education with AI: Exploring the transformative potential of ChatGPT (Adiguzel et al., 2023)
 - **Few papers for chatGPT for dyslexic people**



A new era: generative AI for Supporting Dyslexic Learners

chatGPT-4

- *Learning tools*
 - Personalization
- *Improving Creativity*
 - Encouraging to develop new ideas
- *Improving Engagement*
 - One can interact without fear of being criticized
- *All around support*
 - Aiding in the course learning
- *Encouraging Inclusion*
 - All people could use it
- *Improving self-esteem*
 - Encouraging communication



ChatGPT-based ChatBot

“Chatbots are **conversational** or **interactive agents** that provide instant response to the user”

(Chinedu and Ade-Ibijola, 2021)

“A Chatbot is **a software (machine)** that talks with a **user (human)**: it is a virtual assistant able to answer a number of user questions, providing the **correct responses.**”

(Clarizia et al., 2018)

Chatbots in Education

- The introduction of **Artificial Intelligence technology** enables the integration of **Chatbot systems** into various aspects of education
- This technology is increasingly being used for **educational purposes**.
- Chatbot technology has the potential to provide quick and **personalised services** to everyone in the sector, including institutional employees and students (Chinedu and Ade-Ibijola, 2021)



The applications of Artificial Intelligence (AI) in Education is growing continuously.
(Okonkwo and Ade-Ibijola, 2020)

Chatbots: examples

ChatGPT

- Produced by OpenAI (2022)
- The most advanced model of intelligent chatbot
- Based on **deep learning models**
- **trained** on huge datasets
- Capable of **answering questions** regarding all or almost all knowledge domains

<https://chat.openai.com/>

DALL-E

- An intelligent system based on the **same neural structure** as ChatGPT
- Able to transform a **text** into an **image**

<https://openai.com/dall-e-3>

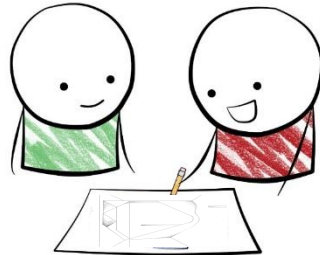
AI4Architect

AI4Architect, a system to assist students to improve creativity in Design domain based on Generative AI

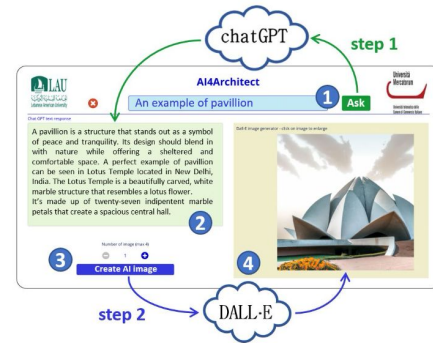
Architectural Design
in higher learning



The Knowledge Domain



The learners



The System

<https://design-edu.bubbleapps.io>

A Web application based on the use, in a pipe configuration,
of ChatGPT and DALL-E 3

AI4Architect

Try the system!



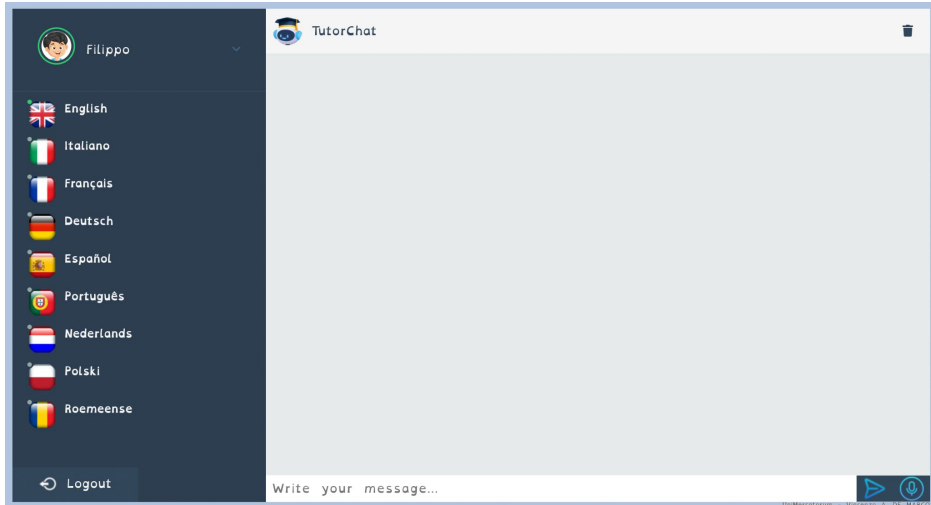
Abrusci, L., Dabaghi, K., D'Urso, S., Sciarrone, F.: *AI4Architect*: an intelligent help system to support students in the design domain. In: The 13th International Conference on Methodologies and Intelligent Systems for Technology Enhanced Learning, MIS4TEL. Lecture Notes in Networks and Systems, Springer (In Press, 2023)

TutorChat

The project aims to provide a chatbot capable to:

1. **Allow** voice input as well as written input.
2. **Send** textual output in response that will be read aloud by the voice synthesiser
3. **Create** graphical and interactive concept maps at the user's request
4. **Try** to encourage the student by providing praises and encouragement through an appropriate communication

TutorChat



- A chatbot for **dyslexic students**
- Age: 8–14
- Built using:
 - generative AI (ChatGPT 4.0)
 - Open Dyslexic fonts
 - Speech-to-text and text-to-speech interface
- Concept maps builder
- Work in progress
- Developed in Python in the Django middleware

TutorChat

Try TutorChat!

<https://sciarro.pythonanywhere.com/>



Some remarks

- In this system AI, Education and Dyslexia are **natively** integrated
- The system was designed by the research team with the collaboration of a psychologist experienced in pedagogy for students with SLDs
- One of the focal points of the system, on which we are still working, is the construction of meaningful communication dialogues that produce:
 - **Self-esteem growth**
 - Cognitive reinforcement
- Meaningful learning through the **concept mapping activity**
- **Inclusion**: this tool could be used also by non-SLD students

Some remarks

- Generative AI is undoubtedly revolutionising the way we teach and learn
- Right now, the education field is going through a moment of confusion/transition, somewhat undermined by the advent of generative AI
- Students with dyslexia, when attending a MOOC are alone and they should be supported in any case
- Intelligent chatbot could be a **winning tool** as long as it is personalised and expresses appropriate communication
- The chatbot should be created by a collaboration among experts from both the medical, psychological and AI fields

Some open problems for MOOCs

- **Privacy**: students should declare to be dyslexic in order to activate the appropriate chatbot
- **Adaptation** is a key factor. Dyslexia presents different levels: how to adapt the chatbot?
- **Communication**: the chatGPT engine should be fine-tuned by a library of communication intents
- **Validation**: the validation step is very important. Is always possible to validate the system using a significant number of learners?
- **Information Reliability**

From all the above considerations, I wonder: **to what extent can the chatbot replace a real tutor?**

Thank you!

Any questions?