





Playful AI Prototypes to Support Creativity and Emotions in Learning

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Abstract. How will learning “look” in the future? Everyone learns—and we do so in a creative and emotional way. However, learners’ creativity and emotions are often not explicitly included in the design process when exploring how technology can be used to provide new learning opportunities, which could result in shallow learning. One way to support such learning with technology could be playfulness. The current paper reports on some of our ongoing experiences in recent years using a playful design perspective to develop three educational Artificial Intelligence (AI) prototypes. Tackling applications intended to facilitate freedom, ease, and engagement in learning, the prototypes comprise an intelligent tutoring system, an automatic display tool, and a hand-waving detector. In closing, some lessons learned are shared to inform subsequent designs.

Keywords: Educational AI · AI prototyping · Computational creativity · Artificial emotions · Playful learning · EdTech

1 Introduction

Education is a crucial human right linked to benefits such as reducing poverty¹ and promoting health and well-being [16]. Everyone learns—and we do so in a creative and emotional manner:

For example, constructivist learning theory, embraced by many teachers, contends that students actively and creatively construct their own knowledge, sparking intrinsic motivation [9]. As well, creativity is a fundamental cornerstone of advanced learning, as the basis for the “extended abstract” and “creating” categories in the Structure of Observed Learning Outcomes (SOLO) and revised BLOOM taxonomies [2, 10]. Likewise, it is known that positive autotelic emotions like enjoyment, engagement, and curiosity are crucial, and from the balance of skill and challenge suggested by Flow Theory and the Zone of Proximal Development (ZPD) [8, 17], that it is normal for learners to experience some degree

¹ <https://en.unesco.org/news/what-you-need-know-about-right-education>.

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also of negative emotions like confusion and frustration. Interest in such emotions is increasing, in parallel with a trend in design to consider the wider picture of a learner’s experience (UX), rather than only if an educational artifact is usable or not.

At the same time, educators are looking for new ways to offer improved learning opportunities. Gone are the days when we need to remember every detail of an abstruse formulation, or buy and lug around expensive, heavy books filled with answers to questions we never had, in the hopes that they might one day be partly useful. Now we search and communicate nearly instantly, like “cyborgs” that retain a crucial part of our knowledge in our flesh brains while delegating the remainder to our digital brains in the cloud. In the face of continuous challenge—such as a two hundred billion dollar gap in annual education funding related to the UN’s Sustainable Development Goals²—one “beacon of hope” for further innovation is Artificial Intelligence (AI), which (despite some hype) could reduce teacher workload and improve student learning: Recent plans from the US, China, and Europe for increased investment in AI are in the billions of dollars, which in recent years has resulted in some exciting breakthroughs in game-playing and science (e.g., Jeopardy, Chess, Go, and protein folding) [4]. The dream is that this kind of development will lead us to new heights in our ability to learn and apply knowledge.

Yet, engineers developing AI technologies often do not explicitly design for creativity and emotions. Some general challenges with designing for creativity in education include overloaded curricula and lack of time, unclear assessment, and mismatched expectations and perceptions [1]. Likewise, emotion is a highly complex psycho-physical phenomenon involving cognitive appraisals, subjective feelings, somatic symptoms, and affect displays, related to sentiment and mood, that defies simplistic modeling (the so-called “affective gap”). The main challenge here is that we don’t understand these constructs well ourselves, let alone how to embed them into digital functionality; as such, artificial emotions and computational creativity have been called “especially challenging” and a “final frontier” in AI [3, 6].

Thus, we are faced with a vast, highly complex design space—no one yet knows how AI will shape the future of education. To gain some initial insight, the current short paper describes a number of our ongoing experiences in recent years toward exploring the integration of AI and education in a way that supports creativity and emotions, following the paradigm of *playful learning*:

- First, we narrow the scope based on discussions with our teachers, focusing on applications that could enhance *freedom*, *ease*, and *engagement* in learning. These goals are defined and grounded in the literature in Sect. 2, and used to derive three specific cases to explore.
- Next, for each case, we design a prototype, applying the principles of playful design and prototyping: Playful design suggests that play can be a stimulating approach to support experiential learning also in adults, which encourages

² <https://en.unesco.org/news/unesco-warns-funding-gap-reach-sdg4-poorer-countries-risks-increasing-us-200-billion-annually>.

creativity and positive emotions such as enjoyment [15]. Finally insights are reported in exploring the resulting prototypes with users, in Sect. 3.

Thus, the aim of this paper is to share some lessons learned—toward stimulating ideation and discussion that could contribute to developing our theory of computational creativity and emotions in relation to educational AI tools, while also suggesting solutions to some real challenges hindering progress.

2 Related Work

Some specific cases to explore had to be identified, but creativity and emotions could play a role in various learning applications: For example, in the areas of EdTech, Educational Data Mining (EDM), and Learning Analytics (LA), AI is continually and increasingly being incorporated into learning tools, to help with applications ranging from grading and skill assessment, to knowledge/engagement tracing, problem detection (lesson gaps, social isolation), teaching assistance (conversational agents or robots), and recommendations (for courses, programmes, group members, or teachers). Here, to guide our exploration, we focused on our own idea—based on our perception of the needs of our teachers and students—that education should also be characterized by freedom, ease, and engagement:

Freedom. Freedom here means that students and teachers should have autonomy and control over how they learn. One example of how to potentially enhance students’ freedom is with Intelligent Tutoring Systems (ITS). Given the merits of flexible, asynchronous learning, as well as the effectiveness of one-on-one classes, and a widespread need for personalization to address gaps in heterogeneous classes, ITS have long been a “bread-and-butter” dream of the educational futurist. In general, this effort has been complicated by high development costs, silo effects, and traditions in the field, that have led to often using simplified learning approaches such as multiple-choice questions which are not optimal for stimulating creative and emotional processes. Although there is continual progress—for example, the importance of inquisitive creativity for agents has been described [18], and eye tracking goggles are being used to assess creativity [11] and detect negative emotions such as boredom when students look away from an ITS [7]—there is still much to be explored. As Ogan et al. describe, current approaches for trust-building are typically limited to simply saying a student’s name and smiling, but “a more involved process ... is likely necessary” [12]. Also given that trust and playfulness have been positively linked previously, we believe there is merit in exploring a playful ITS prototype.

Ease. Learning typically requires effort, but not all work associated with learning might be required or helpful; ease here means that bothersome tasks that don’t contribute can be automated. One task that requires work from teachers who often have little time is preparing learning materials, which are typically inflexible and resistant to adaptation. For example, in the data age, simulations and

visualizations including augmented reality [5] promise to facilitate better understanding and avoid drowning students in “rigorous” details, but developing such materials takes time; language teachers as well are often interrupted by students who wish to know how a word is spelled. Therefore, we foresaw a potential need for a dynamic display tool that could adaptively generate visualizations such as images or words to describe what a teacher is discussing.

Engagement. Engagement here relates to motivation and attention. It is known that physical activity aids creativity and positive emotions [13], but students especially in STEM subjects can spend much time seated in front of a computer. Furthermore, allowing students to be more active, and in control of their learning, is desired, in line with self-determination theory and autonomy-supportive teaching [14]. Therefore, a program that can facilitate engagement via physical activity and enhanced autonomy could be useful.

3 Methods

Based on the derived cases, three prototypes were designed and implemented, as shown in Fig. 1, 2, and 3 :

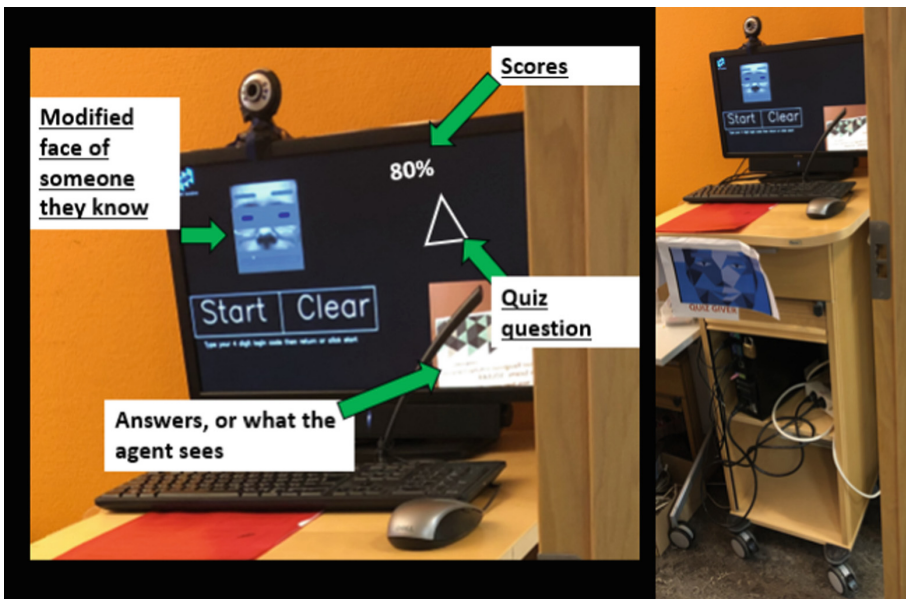


Fig. 1. Questioner. A quiz-giving agent squats upon a wheeled lectern.

Questioner. The basic idea of this prototype was to provide students with a chance to receive asynchronous, continual (weekly) feedback on their progress



Fig. 2. Displayer. A Baxter robot displays words that a teacher speaks during a class on its small display screen.



Fig. 3. Waver. A student waves in the foreground during a class to indicate that they would like to hear more about a topic.

during a course via quizzes, to reduce their stress before exams. We also saw opportunities for personalizing content to students from different backgrounds, who might have gaps in their knowledge. The prototype consisted of a desktop, with a keyboard, mouse, and camera for input, and a monitor and speakers for output, housed on a wheeled lectern to be able to move between classrooms easily. To access appropriate quizzes, students inputted a personal code, then chose from a list of quizzes, and typed in their free answers. To seem engaging, like in an interaction with a person, the prototype agent was set to blink, and to also provide suggestions if students did not quickly answer quiz questions. Response times were logged, although they were not used. Internally, the prototype used OpenCV³ for face detection and keyboard/mouse event handling, and CMU Pocketsphinx⁴ for speech recognition, on top of Robot Operating System (ROS)⁵. Matching with keywords was conducted to determine if answers are correct. Although the main goal of this prototype was to allow students more freedom in being able to choose when they wanted to learn and how they wanted to interact, we also sought to support ease via the familiar interface (humanoid, mouse, and keyboard) and engagement through the prototype's interactivity (not just multiple choice questions).

Playful responses were triggered if the prototype detected behavior from the user that seemed playful, as described in Table 1; for example, the prototype moved its face away slightly in a random direction if a student clicked on it. Furthermore, a familiar face, the face of the main teacher in the course, was also used to be playful, and the prototype was set to increasingly smile as more questions are answered correctly. Thereby, the aim was that a student could feel creative through exploring the prototype's varied and potentially unexpected reactions and suggestions. Positive emotions were supported via the prototype's positive but logical responses (e.g., potentially allowing emotional contagion), and the potential to build trust via humor.

Displayer. The basic idea of this prototype was to continually display what a teacher says during a class. A headset microphone was used to capture the teacher's words. Keywords (nouns) were then displayed, along with an image visualizing them. Images were downloaded via Google, either on the fly, or before class for speed. Images and words to display could be shown on any screen, either a monitor used by a single student, or a large screen for a class. The inspiration for this idea came from the science-fiction movie, *Blade Runner*⁶, in which a detective used voice commands to enhance and manipulate an image to find an escaped android. The closest tool currently to our prototype might be an intelligent speaker like Amazon Alexa⁷ or Google Nest⁸—although, to use them, a teacher would constantly have to ask the device to show images, which would not

³ <https://opencv.org/>.

⁴ <https://cmusphinx.github.io/>.

⁵ <https://docs.ros.org/>.

⁶ https://en.wikipedia.org/wiki/Blade_Runner.

⁷ https://en.wikipedia.org/wiki/Amazon_Alexa.

⁸ [https://en.wikipedia.org/wiki/Google_Nest_\(smart_speakers\)](https://en.wikipedia.org/wiki/Google_Nest_(smart_speakers)).

Table 1. Playful behavior from users and the Questioner.

User action	Agent response
Clicking the agent's eyes	"Hey, that's my eyes!", "Ouch, stop clicking my eyes", "My eyes are very sensitive you know", "Help, help!", "The paaaaa, the paaaaa"
Clicking the agent's face	"Stop slapping me!", "Didn't your mother teach you that it's not nice to touch people's faces", "Are you looking for something to do?", "Oh, that actually felt kind of good"
Waiting after answering	"Good question, eh?", "Do you see why that is the answer?", "Nice weather, huh?"
Calling the agent "cool" or "handsome"	"Thank you!"
Moving face in front of agent	The agent's eyes moved to try to look at the person's face

work for a class. Internally, the prototype was built using speech recognition via CMU PocketSphinx, on top of ROS, in conjunction with web-scraping python code, and OpenCV to display results. Thus, the main goal of this prototype was to make teaching easier by not requiring the production of slides, but the prototype also allows students to freely choose if they want to "see" what is being talked about, and engages via the saliency of the moving display.

The aim was that playful learning could result from the novelty of the prototype, as well as imperfect performance from speech recognition and image searches that might yield odd or humorous results (for example, showing an action figure or power converter instead of a machine learning technique for "Transformer"). Creativity could result from such playfulness by facilitating visualization and providing unexpected stimuli; positive emotions like enjoyment could be supported by the game-like feeling and humor.

Waver. The basic idea of this prototype was to encourage students to wave to decide between two options for how to proceed in a class: for example, if they would like to hear more about a topic, yes or no. The teacher pressed keys to "initialize" the system and quantify the class's response. Internally, the prototype recognized waving via "background subtraction", where it compares the classroom scene before waving and during waving, and finds the sum of the differences in intensities. One potential alternative could be to detect motions via color tracking; the proposed approach however avoids potential problems with colored clothing or backgrounds, or requirements for physical props that students or teachers might have to remember to bring. Although the main goal was to engage students, the prototype could also allow more freedom and ease (a single student can exert a stronger influence over the class than when hands are counted, and not require a teacher to make an assessment themselves).

We expected that playful learning could result from the novelty and physical nature of the prototype, as well as the possibility that students might seek to perform exaggerated motions to compete or outbid one another. Creativity could be supported by new experiences and the physical exercise (better thinking), and enjoyment from the exercise and humor that emerges.

3.1 Lessons Learned

The three prototypes were trialled over three years, mainly in an engineering course called “Design of Embedded and Intelligent Systems”, offered to second year master’s students at our university in southern Sweden. The prototypes were further reported on and discussed in various workshops, involving over a hundred teachers from universities in southern Sweden. Due to the emergence of COVID-19, work on all three prototypes was temporarily halted, to focus on the large changes required to move from completely campus-based teaching to online teaching; thus, we also provide some thoughts below on how the prototypes could be adapted for post-COVID learning.

Questioner. In 2017, the prototype was brought to the classroom so students could use it in pauses, but we noticed a “Soretian bottleneck” effect in which many students gathered around but few could interact at any given time. In 2018, the prototype was deployed for two weeks at an unnamed but visible location at the university; students were encouraged to search for it, with location-based learning in mind, as well as to give them an opportunity to become familiar with the university. Unfortunately, few students searched for and found the prototype (only one group out of five). In 2019, the prototype was used for three courses (adding “Programming, Data Structures, and Problem-solving” as well as “Artificial Intelligence”). It was co-located with supplemental instruction classes to make it easy for students to find. To encourage regular use, each quiz was set to only appear for a given week. Although not all students experienced the prototype, the changes resulted in somewhat increased usage. To obtain some initial feedback, we sent out a Google form survey, which a few students filled out, as in Table 2. Based on a comment, capital letters were automatically changed to lower case in answers before processing; however, sometimes “close” answers might not be correct, so methods like cosine similarity were deliberately not used. As well, the students that felt the camera seemed suspicious said that they had playfully tried to compliment their teacher in front of the prototype, in the possibility that someone might be listening or watching. (To avoid misunderstandings, the teacher clarified that such functionality would be unethical, and briefly walked them through the code, available publicly on GitHub, so they could see there was no monitoring capabilities.) Some other observations were also made:

- Some students reported playfully “hacking” the accuracy score by repeating questions, despite knowing that the prototype was completely optional for use and had no bearing on their grades. This could be beneficial to help

students to learn material through repeated exposure, but could also affect any statistics on response times, where applicable.

- There were social effects: Some students gathered around when the teachers came to turn the prototype on, wanting to see “hidden” features such as logs, etc. Also, groups of students came to use the desktop at the same time, using just one account to see questions. One student mentioned taking photos of the quizzes to share with group members.
- The camera affixed to the monitor had trouble detecting tall students (and on one occasion also froze when pulled, stopping the prototype from tracking faces with its eyes).
- The desktop was heavy, deterring theft, but despite the wheeled lectern it was somewhat irritating to move to different classrooms each time, due to abundant doorway thresholds at our university.
- Some students entered the courses late due to visa problems, and therefore there was always work trying to provide new codes to access the prototype.

Some challenges include the cost in teacher time to prepare quizzes, assuming these do not already exist, and to bring the prototype to the classrooms where it will be used—as well as potential ethical problems with using cameras and microphones and calculating statistics like accuracy scores or average response times. To use the agent in the post-COVID online era, a web interface would be required; challenges would include how to verify that students had cameras and microphones, or that the prototype could yield a playful interaction with various setups.

Table 2. Feedback on the questioner.

Positive characteristics	Suggestions for improvement
Engaging (3) (“A good alternative/help for studying. Helpful for me as I have a hard time keeping my concentration up while Reading.” “The human voice of questioner is interesting.” “Friendly user interface”)	Not enough questions (2) (e.g., “Not having all the questions available. Sometimes you would like to have a session where you could sit down with the stations for more than a couple of minutes.”)
Unique	Should be smarter (“The check of answer is not very smart, for example it thinks using capital or not is different.”)
	Ethics should be clear (“The camera part of it made it look a bit suspicious, because it was capturing live video.”)

Displayer. In 2017, the display screen of a robot “teaching assistant” was used to display concepts, but the screen was small, making it difficult to see well. In 2018, some automatically harvested images were incorporated into course

slides. Furthermore, an ability to freeze the dynamic displaying via a key press was added, since a student might not be able to keep up with the display, which could distract rather than help them to know more. Challenges include the speech recognition accuracy, the validity of the image search results (appropriateness of downloaded images), delays from sometimes having to download large files, and licensing of images. To use the prototype post-COVID, a teacher could log in with an extra device onto an online class platform such as Zoom, and adapt the video stream to show the results of the Displayer in one window.

Waver. The first version in 2017 only considered instantaneous motion (in one image frame), thereby potentially missing much of the students' waving. Some students also expressed worry that they might be acting against their peers' interests (which might have also been affected by the fact that the prototype was not anonymous), but noted that they could possibly get used to it. In 2018, motion over a few seconds was calculated, and the response was more enthusiastic: some students waved for both alternatives they were offered (both "yes" and "no"), and asked questions about the underlying algorithm. Challenges included the difficulty of detecting motions from everyone gathered around a camera during workshop demos in small rooms, that small movement of the camera at the wrong time by the teacher could result in large perceived motion, that the teacher is required to press some keys (further automation would be useful), and identifying potential ethical problems with using sensors or detecting student participation. Allowing students more opportunities to select learning topics could also increase a teacher's workload (like in a flipped classroom), and although waving could be democratic (for example, each student could wave for each presentation slide or quiz to indicate that they have understood it), it is unclear if a class should learn at the pace of its slowest member. To avoid seeing people's faces, an overhead camera could be used to detect head motions, or a camera under a desk could record foot movements, although in the latter case occlusions could be problematic. To use the prototype post-COVID, a camera could be set up to view the students in a gallery on an online class platform like Zoom; there, some challenges might be that all students might not be shown in larger classes, and that students often turn off their cameras or claim to not own a working camera (students might also not wish to wave on camera if classes are to be recorded).

4 Conclusion

The current short paper reported on our work-in-progress in designing educational tools that comprise AI:

- We proposed that educational AI designers should explicitly consider creative and emotional processes, for which playful learning could be a useful paradigm.
- We described three playful learning prototypes developed based on our assessment of the literature, and the needs of our teachers and students for freedom,

ease, and engagement in education. Code for the prototypes has also been publicly released⁹.

- We described some lessons learned from developing the prototypes, also suggesting future directions for improvement, and adaptation strategies for the post-COVID learning environment.

As we continue to improve the quality of our prototypes and check new possibilities, it is our aim that these ideas could help to stimulate discussion, toward enhancing education experiences.

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⁹ <https://github.com/martincooney>.

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